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Graphical User Interface Development and Design to Support Airport Runway Configuration Management

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September 2015

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Introduction

The objective of this effort was to develop a graphical user interface (GUI) for the National Aeronautics and Space Administration's (NASA) System Oriented Runway Management (SORM) decision support tool to support runway management. This tool is expected to be used by traffic flow managers and supervisors in the Airport Traffic Control Tower (ATCT) and Terminal Radar Approach Control (TRACON) facilities.

NASA Research for Runway Configuration Management

The air traffic system is becoming increasingly complex. New technologies and operational procedures are being deployed to address mounting pressure, increase system capacity, reduce delays, improve aircraft efficiency, reduce fuel burn for both operating cost and environmental benefits, increase reliability in poor weather conditions, and improve system safety. The National Aeronautics and Space Administration's (NASA) Aeronautics Research Mission Directorate (ARMD) has pursued focused research to help the nation achieve revolutionary advancements in air traffic management. The Joint Planning and Development Office (JPDO) NextGen Concept of Operations (JPDO, 2010) provided direction for ARMD's pursuit of research toward improving the National Airspace System (NAS), stating that "during the next two decades, demand will increase." While the magnitude of potential traffic increases has been debated, increased demand, fuel costs, and environmental awareness will all necessitate enhanced air traffic management system capabilities.

The efficient use of runways is of paramount concern for improving efficiencies in the NAS. To address necessary changes in the NAS, NASA developed a research plan under the Airspace Systems Program (ASP). The most current version of the NASA ASP plan (NASA, 2008) cites the impact of effective runway management, stating: "*one of the biggest limiting factors in expanding air traffic capacity lies in airport operations, where a multitude of factors can cause flight delays and other incidents, the effects of which can cascade throughout the NAS. Airport capacity and efficiency is constrained at the individual airport level by surface operations (taxiways, ramps), runways (individually or interacting), and at the metroplex level due to interactions in the flow between nearby airports. Interacting flows between nearby metroplex airports are intricately linked to runway configuration and scheduling at the individual airports*

and must be treated as a system if system capacities and efficiencies are to be obtained." Architects of NASA's Aviation Safety Program determined that, among the capabilities being developed to support NextGen, a complimentary runway management capability was needed.

In this context, the SORM concept was developed to directly address these needs. Planning the airport configuration has the potential to deliver substantial benefits at some airports within current operations and considerably greater benefits in the future as other technologies and procedural changes increase the airport configuration flexibility. The following sections describe first the current methods for conducting runway management, and then the SORM concept and its constituent tools.

Current Runway Management Operations

Runway Configuration Management is considered to be the process of designating the active runways, monitoring the active runway configuration for suitability given existing factors, and predicting future configuration changes. Current runway management can be described in terms of tactical airport configuration, coordinated runway scheduling, and strategic airport capacity planning. These elements of current operations are briefly described below. Lohr and Atkins (2014) describe these in more detail.

At most airports, the airport traffic control tower (ATCT) supervisor or controller-in-charge (CIC) has primary responsibility for selecting which runway configuration should be used and any other procedures for which options are available. The degree to which efficiency can be achieved is a function of many factors including taxiway structure, area availability to absorb traffic overload, and availability of low weather instrument approaches. The primary considerations for runway selection are wind direction and speed, but other considerations include: meteorological conditions, traffic demand, shear/microburst alerts/reports, adjacent airport traffic flows, severe weather activity, instrument flight rules departure restrictions, environmental factors, intersecting arrival/departure runways, distance between arrival runways, dual purpose runways (shared arrivals and departures), land and hold short (LAHSO) utilization, availability of high speed taxiways, potential for use of reduced (2.5 nm) separation rule for arrivals, airspace limitations/constraints, procedural limitations (missed approach protection, noise abatement, etc.), taxiway layouts, and terminal flow of traffic.

In current operations, coordinated runway scheduling is accomplished by frequently basing runway assignments on a common procedure. Departure aircraft are assigned to the runway that is most closely aligned with their initial direction of flight. Sequencing strategies are used to ensure divergent headings between successive departures. Significant changes in sequencing are generally precluded by respecting the first-come, first-served principal and by controller workload. Other factors that influence departure runway assignment are runway length requirements for larger aircraft, noise restrictions, cross winds, and traffic volume. Arrivals are generally assigned runways closest to their arrival fixes, although when possible, efforts are made to reduce taxi distance. Load balancing for both the routes through the terminal area as well as the runways result in exceptions to this rule, and aircraft sequence can be altered to reduce impact of wake vortex separation requirements.

Strategic airport capacity planning occurs for those decisions that occur hours in advance. These can be based on forecasted weather when operations between arrivals and departures are coordinated, which is generally not the case in today's environment. For example, if severe weather will reduce the capacity of an airport and result in many flights being delayed, the most efficient place for those flights to incur the necessary delays is on the ground prior to departure, with their engines not yet running. At this long time-horizon, specific decisions about the airport configuration that will be used during the severe weather have not been made and, therefore, are not available to the traffic flow management (TFM) decision process. However, the TFM decision process must be informed by some estimate of what will happen at the airport.

System-Oriented Runway Management Concept

Currently, SORM is comprised of three components: Tactical Runway Configuration Management (TRCM), Combined Arrival/Departure Runway Scheduling (CADRS), and Strategic Runway Configuration Management (SRCM). A brief description of these components is provided below, but more details are available in the SORM Concept of Operations (Lohr & Atkins, 2015).

Tactical Runway Configuration Management (TRCM) plans the airport configuration over a timeframe appropriate for air traffic personnel in the ATCT and TRACON to make runway configuration and operating procedure decisions used to control arrival and departure traffic.

TRCM also selects aggregate policies for the active runways' usage. The FAA uses the term "Airport Configuration Management" to refer to the TRCM capability.

Combined Arrival/Departure Runway Scheduling considers runway assignments and aircraft sequencing, airport surface, and TFM factors. The concept does not imply any particular approach to achieving runway operations that are efficient from the perspective of the complete trajectories between parking gates and transition fixes. The envisioned CADRS capability is intended to efficiently plan the use of the selected runway configurations. This includes consideration of arrival and departure traffic as well as aircraft taxiing across runways. Combined Arrival/Departure Runway Scheduling is the most tactical in nature; it plans how individual flights should use available runways and is subject to (or in exception to) the aggregate policies selected by TRCM.

Strategic Runway Configuration Management forecasts the airport configuration over a longer time horizon for the purpose of providing airport capacity forecasts for use in traffic flow management—planning traffic management initiatives (TMIs) several hours in advance. While the output of this function would be a coordinated capacity forecast, underlying this forecast would be determination of the most likely airport configurations and times at which the configuration would change.

System-Oriented Runway Management uses runway configuration and other runway usage manipulations to improve the efficiency of arrival and departure operations at an airport while considering traffic flow management objectives and restrictions. While the concept encompasses control mechanisms used by many other concepts, such as runway scheduling, SORM is unique in its inclusion of runway configuration and other aspects of airport configuration as key control mechanisms for maximizing overall operational efficiency. The concept provides for the incorporation of inputs from all service providers that are responsible for the administration of air traffic operations, in addition to the system users (airlines and general aviation, among others) and airport operators (those who essentially "own" the airport). SORM provides information to the human controller, but the human always makes the final decision and executes runway configuration and use changes. As such, the user interface to SORM is of paramount import. This document describes the development process for a candidate GUI to support the controllers' effective use of the SORM concept.

GUI Development Methodology

The Situation Awareness Oriented Design (SAOD) approach was used in this development (Endsley & Jones, 2012). The SAOD process is a user-centered approach that covers all aspects of system design from requirements analysis, to design development, to evaluation of the resultant designs. This approach has been effectively utilized and validated across a variety of domains and results in validated, user-accepted GUI designs. SAOD is comprised of three main stages: requirements analysis, GUI design, and measurement (Figure 1).

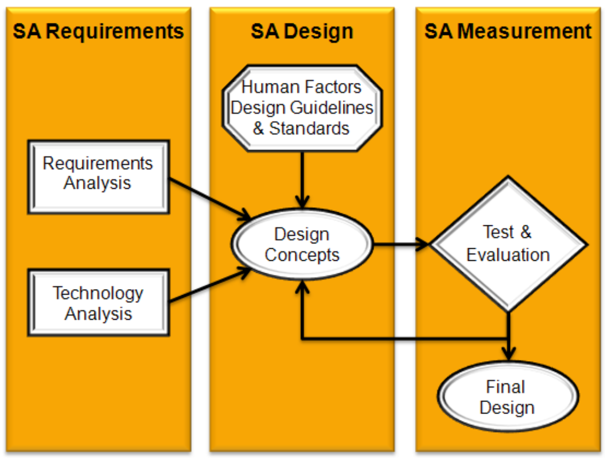

Figure 1. Situation Awareness Oriented Design (SAOD) approach.

The first phase of the SAOD process focuses on understanding requirements, both from a user perspective and from a technology perspective. To ascertain users' requirements, SAOD utilizes a form of cognitive task analysis called a Goal Directed Task Analysis (GDTA) which reveals user goals, decisions that must be made to achieve those goals, and information required to make the decisions. This analysis not only defines the goals associated with traffic management, it also identifies the type of information that needs to be easily accessible on the GUI to support traffic management activities and provides clear guidance how that information needs to be combined to support optimal decision making. In addition to the GDTA, the SAOD process includes a traditional function analysis (FA) to define the functions and tasks that must be accomplished. To understand the technology perspective, a work domain analysis was conducted to model the functional constraints of the SORM systems. Users' requirements and

results from the technology survey were integrated to create a set of information requirements essential for the success of the SORM tool.

The second phase of the SAOD process combines the results of the analysis phase with Situation Awareness (SA)-oriented design principles as well as human factors design guidelines and standards to create common, intuitive, goal-based GUI designs. Each design is based on a goal drawn from the GDTA, thereby providing designs that are goal-centric, support the decisions that need to be made relative to that goal, and provide appropriate information to support decision making. The results of this design process, applied to the SORM task, are detailed schematics of a GUI to support traffic management activities.

The third phase of the SAOD process entails systematically evaluating the GUI to ensure the designs support those involved in traffic management activities. A full evaluation involves a variety of metrics that, when combined, provide a robust picture of the ease with which the user can develop and maintain an appropriate situation awareness, exhibit the required level of performance, and experience an appropriate level of workload. This document focuses on the development process and resulting GUI design for the SORM tool. Each of these phases and the resultant artifacts are described in the following sections. In the current project, the evaluation phase was limited to two informal GUI evaluation sessions. The document concludes with a plan to more fully evaluate the SORM system using low fidelity cognitive walkthroughs, part task testing, and high fidelity simulation experiments.

This methodology was applied to a review of interviews conducted at three air traffic control tower/TRACON locations, and the materials obtained from personnel at these locations. The artifacts resulting from this phase of the project include (1) the work domain analysis, (2) the GDTA, (3) the FA, and (4) the resultant information requirements.

Work Domain Analysis

The work domain analysis models the functional constraints of the SORM system and the operational context in which it will exist. Table 1 provides an overview of the ATC control centers and functions. Table 2 summarizes tools that support controllers' decision processes in managing runway configurations. The work domain analysis resulted in a high level understanding of information flow within the system, system constraints, and operational assumptions that frame the determination of runway configurations and use. The results of this analysis are documented using six concept maps:

1. **Organizational view**: Shows the organizational structure of relevant stakeholders and how they relate to each other (Figure 2).
2. **Operational view**: Primarily documents the information flow among various SORM-relevant entities (Figure 3).
3. **Physical view**: Models the supporting physical infrastructure of Tower and TRACON operations (Figure 4).
4. **Systems view**: Documents the relationships among relevant controller tools that are in use, and those anticipated to be used concurrently with SORM (Figure 5).
5. **Configuration change view**: Focuses on the information flow regarding configuration changes (Figure 6).
6. **TRCM simulation view**: Illustrates the current MOSAIC ATM TRCM simulation with inputs / output constraints (Figure 7).

These views primarily document relevant entities, relationships, and information flow, and they present the existing operational assumptions in terms of SORM-relevant organizations, physical structures, and computer systems. User-considerations are captured as part of the cognitive task analyses described below.

Table 1: Air Traffic Control (ATC) facilities and positions.

Entity	Function
AOC (Airport Operations Center) Facility	AOCs manage day-to-day airport infrastructure and operations and include emergency personnel. AOC responsibilities at an airport are defined as Airside and Landside. Airside areas include all areas accessible to aircraft, including runways, taxiways, and ramps. Landside areas include parking lots, public transportation, train stations, and access roads.
AOCC (Airline Operations Control Center) Facility	AOCCs schedule and dispatch flights for airlines. They control the aircraft from several hours before a flight to about an hour after the flight. They coordinate with ACTCs to adjust airline schedules in response to off nominal events.
ATCSCC (Air Traffic Control System Command Center) Facility	The purpose of the ATCSCC is to maximize the overall use of the NAS and minimize delays and congestion by managing the flow of air traffic. It coordinates traffic in consideration of weather and other anticipated events (e.g., military maneuvers) and acts as coordinating hub when unexpected conditions occur.
ARTCC (Air Route Traffic Control Center) Facility	As aircraft fly enroute, they enter successive enroute centers (ARTCCs). The purpose of the ARTCCs is to provide air traffic service to aircraft operating on Instrument Flight Rules (IFR) flight plans within controlled airspace, usually at high altitudes and normally during the enroute phase of flight between airport approach and departures.
TRACON (Terminal Radar Approach Control) Facility	The purpose of TRACONs is to control approach/departure airspace to handle traffic in a 30-to-50-nautical-mile radius from the airport. This facility ensures that aircraft are at an appropriate altitude and speed for transition to enroute or tower control. TRACON gives input to the ATCT Supervisor on runway configuration.
ATCT (Air Traffic Control Tower) Facility	The purpose of the ATCTs is to safely and efficiently direct aircraft in the controlled airspace immediately surrounding the airport, and on the runway. This entity is responsible for all active runway surfaces. ATCT provides runway separation for arriving and departing aircraft ensuring that prescribed runway separation exists at all times. They coordinate with Airline Operations Centers as necessary to address aircraft rescheduling.
Traffic Management Coordinator (TMC) in TRACONs and ATCTs	Responsible for the smooth flow of traffic to/from the airport. This position identifies any situation that may constrain the airport's ability to attain the maximum flow rate achievable under the current conditions.
Local Control Position in ATCTs	Local Control is responsible for managing traffic using the runways and in the airspace immediately surrounding the airport. This position bears the responsibility for application of separations standards for IFR arrivals (not on visual approaches) and departures.
Ground Control Position in ATCTs	The Ground Control position in the ATCT is responsible for aircraft and ground traffic on "movement areas," i.e., all taxiways, inactive runways, holding areas, and some transitional aprons or intersections where aircraft arrive, having vacated the runway or departure gate. Ground Control determines the sequence of departing aircraft.
Clearance Delivery Position in ATCTs	Clearance Delivery coordinates with the enroute center and national command center or flow control to obtain releases for aircraft to ensure that the aircraft have the proper route and slot time. Clearance Delivery issues route clearances to departing aircraft, typically before they commence taxiing.

Table 2. Tower/TRACON tools that support runway configuration decisions.

Tool	Functionality
ETMS (Enhanced Traffic Management System)	Predicts, on national and local scales, traffic surges, gaps, and volume based on current and anticipated airborne aircraft. Calculates a schedule of airport configurations to advise decision makers on configuration change decisions.
OIS (Operational Information System)	Provides information on numerous subjects pertinent to the NAS, including GDP, ground stops, airport closures, de-icing, delays, etc.
TMA (Traffic Management Advisor)	Displays arrival demand, ETA, calculates a schedule for arrivals at the runway threshold. The TMA concept does not include the runway schedules being used for controlling landing times, or even the landing sequence or runway assignments.
Traffic Situation Display (TSD)	A plan view of air traffic based on flight plan data intended to provide situational awareness of traffic on a system wide basis (entire country).
Airport Surface Detection Equipment - X (ASDE-X)	A surveillance system using radar, multilateration, and satellite technology to track aircraft and vehicles. In addition to the benefit of any surveillance capability, ASDE-X alerts controllers to potential runway conflicts.
Integrated Terminal Weather System (ITWS)	Provides automated weather information - integrates data and information from FAA and National Weather Service (NWS) sensors such as the Terminal Doppler Weather Radar (TDWR), the Next Generation Weather Radar (NEXRAD), Airport Surveillance Radar (ASR), Low Level Wind Shear Alert System (LLWAS), Automated Weather and Surface Observing Systems (AWOS/ASOS), among other sources.

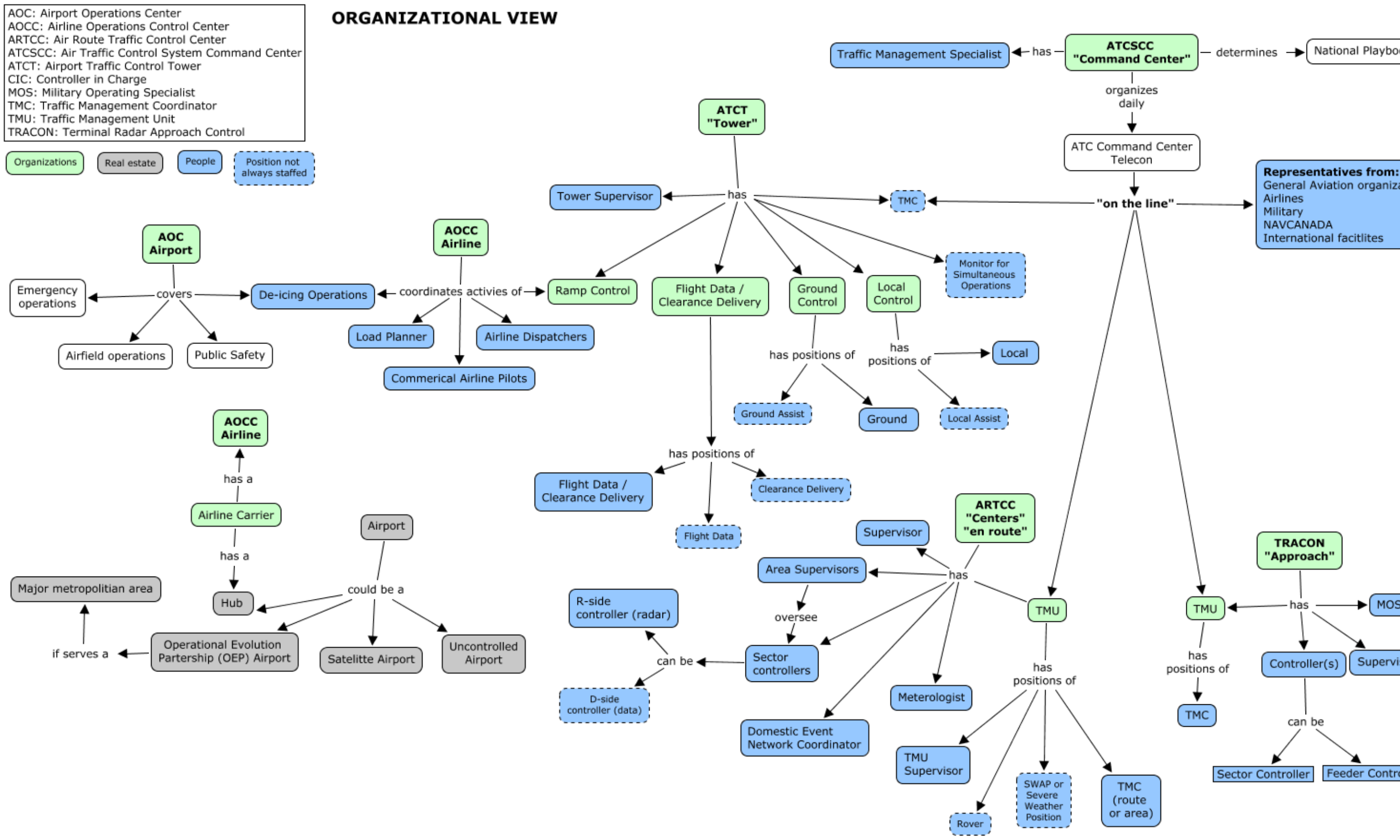

Figure 2. Organizational view.

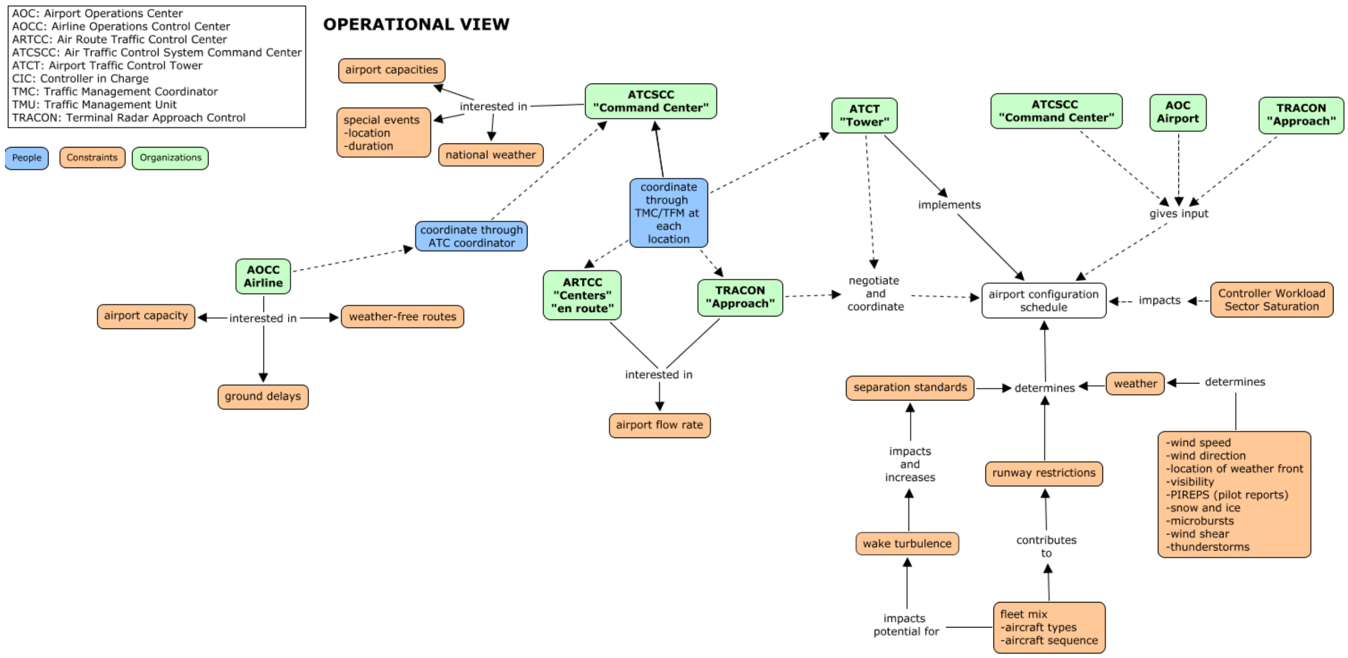

Figure 3. Operational view.

PHYSICAL VIEW

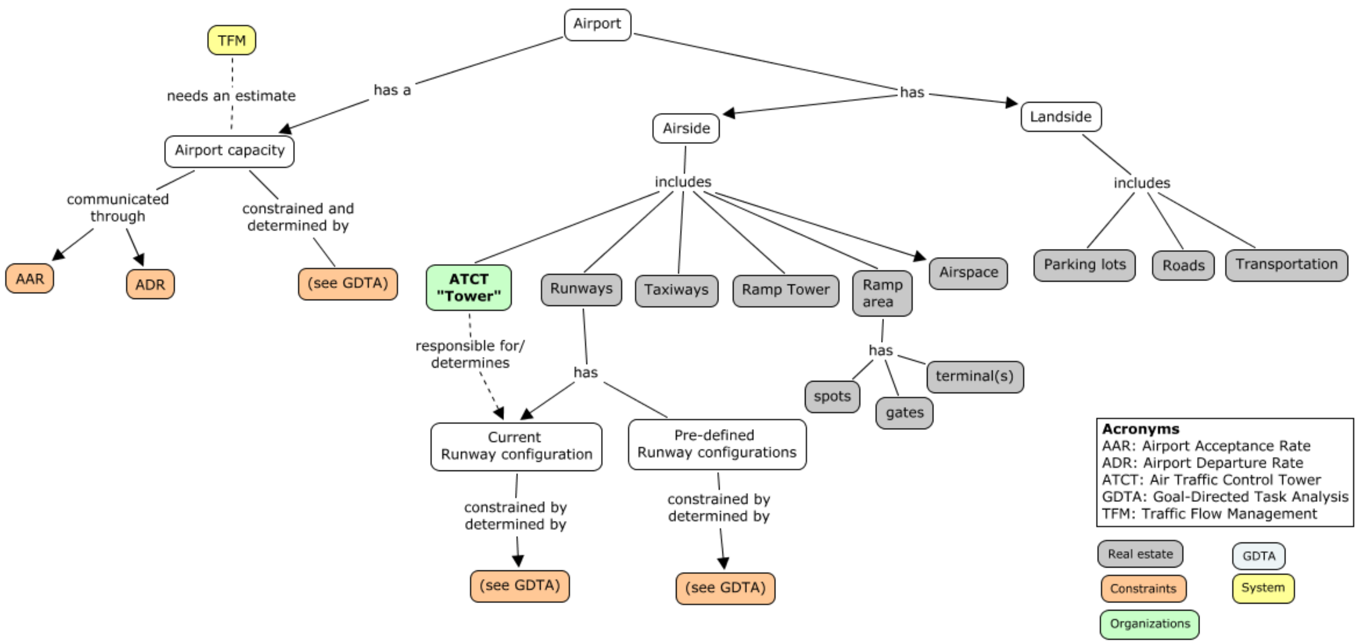

Figure 4. Physical view.

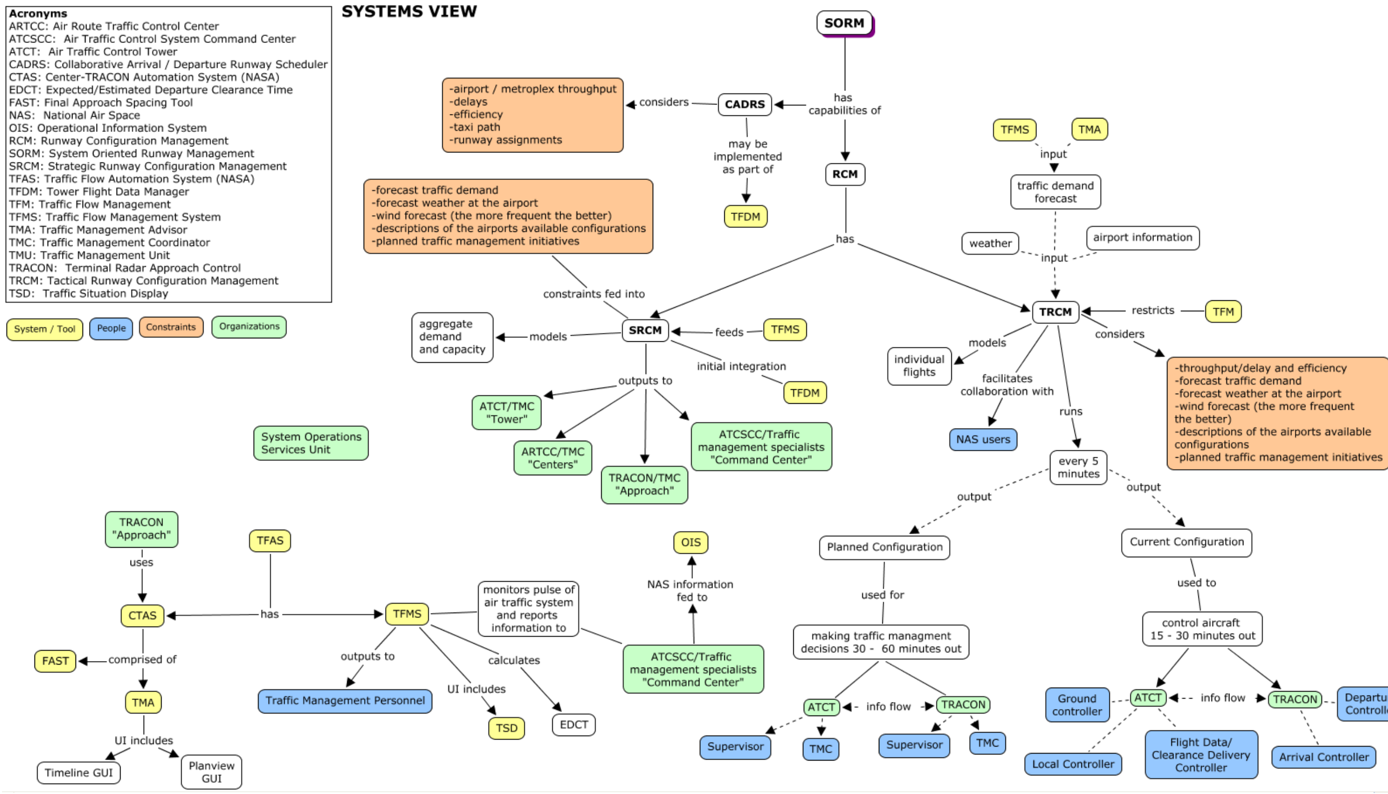

Figure 5. Systems view.

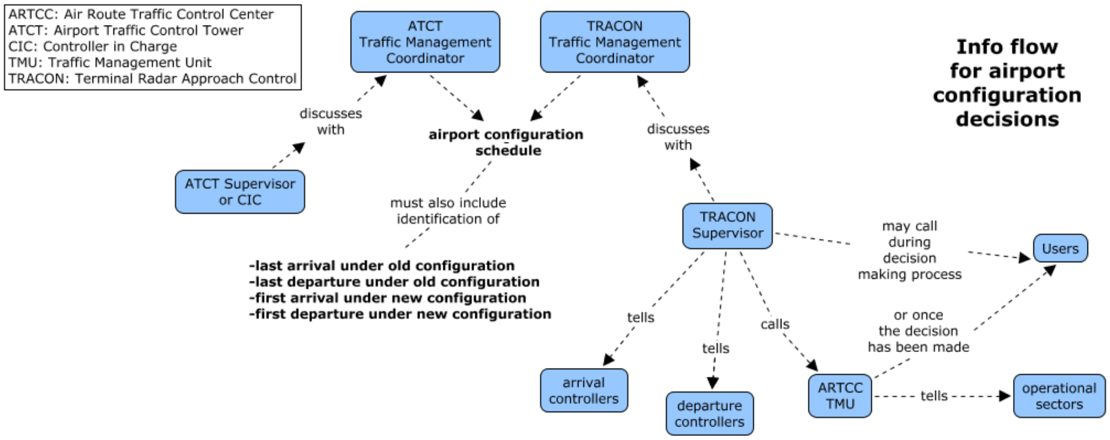

Figure 6. Configuration Change view.

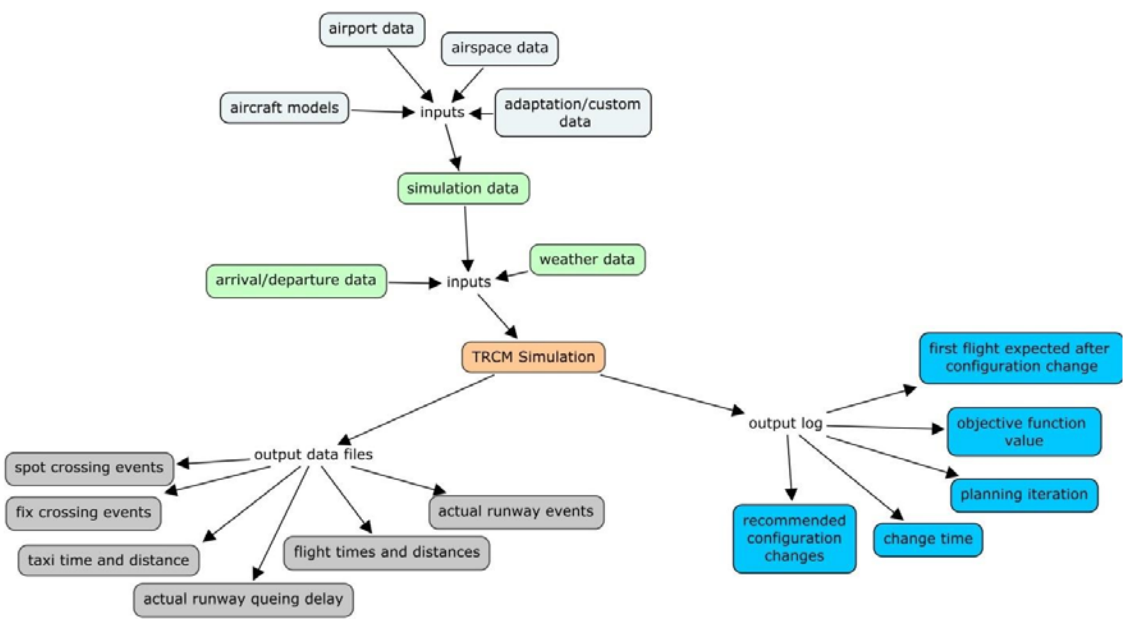

Figure 7. TRCM Simulation view.

Cognitive Task Analysis

Two complementary task analyses captured the goals and tasks that need to be supported by the SORM tools. The first analysis was a GDTA which focused on end user goals, decisions, and information requirements. The second was a FA that focused on the specific functions and tasks that must be performed while making decisions to meet identified goals. The GDTA and FA involved an iterative process of interviewing subject matter experts (SMEs), synthesizing the information provided by SMEs, and then reviewing the resultant analyses with SMEs to ensure accuracy and completeness. Taken together, these two analyses provide a robust description of the task environment and the user's informational and task requirements that will support the next phase of development.

Goal-Directed Task Analysis

The GDTA is a form of cognitive work analysis that describes the Tower and TRACON traffic management coordinators' (TMC) goals, the decisions they must make to achieve their goals, and the information they need in making these decisions. The GDTA not only identifies the specific information TMCs need, but it also identifies how data are integrated and combined to address each decision and to develop higher levels of SA. Thus, this analysis provides specific direction as to what information TMCs need, which information needs to be presented together (e.g., to support a decision and a goal), and how this information needs to be presented to facilitate understanding and task performance. Figure 8 shows the top level of goal decomposition from the overall goal of "Ensuring safe, orderly, and expeditious flow of traffic to and from the airport to support the National Airspace system" into four supporting subgoals, which are then described in terms of their principle decisions. Further decomposition of each subgoal is shown in Figures 9 through 14. Because weather and other intruding events are referenced within several of the subgoal decompositions, these were called out as separate figures (Figure 15 & 16, respectively).

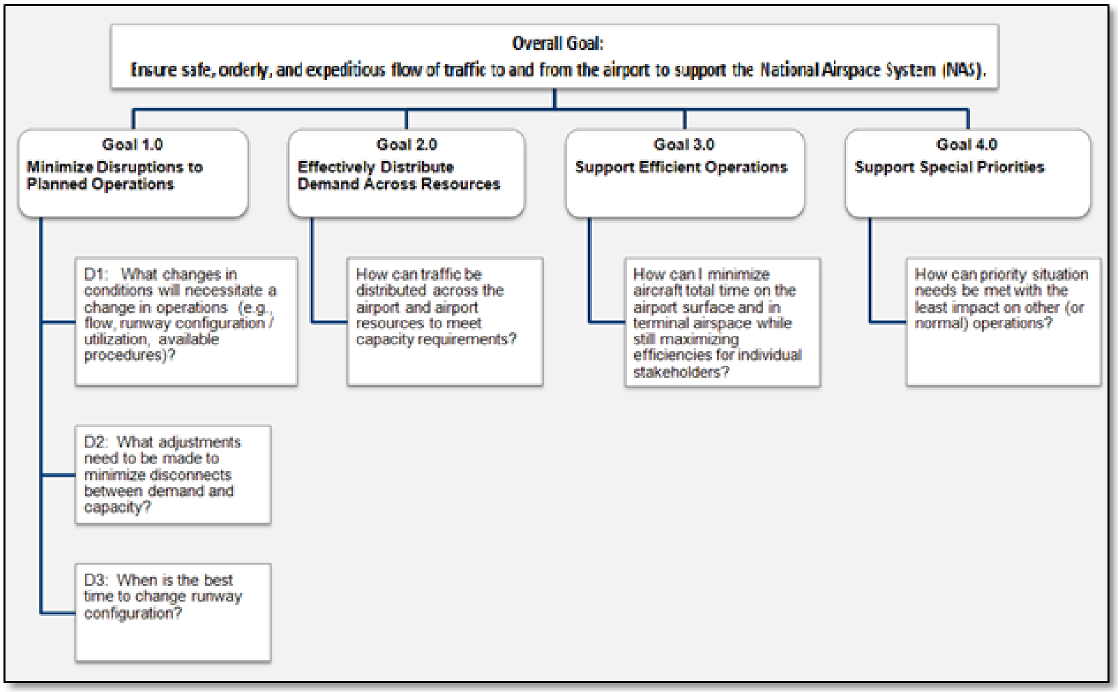

Figure 8. SORM high-level goals and decisions.

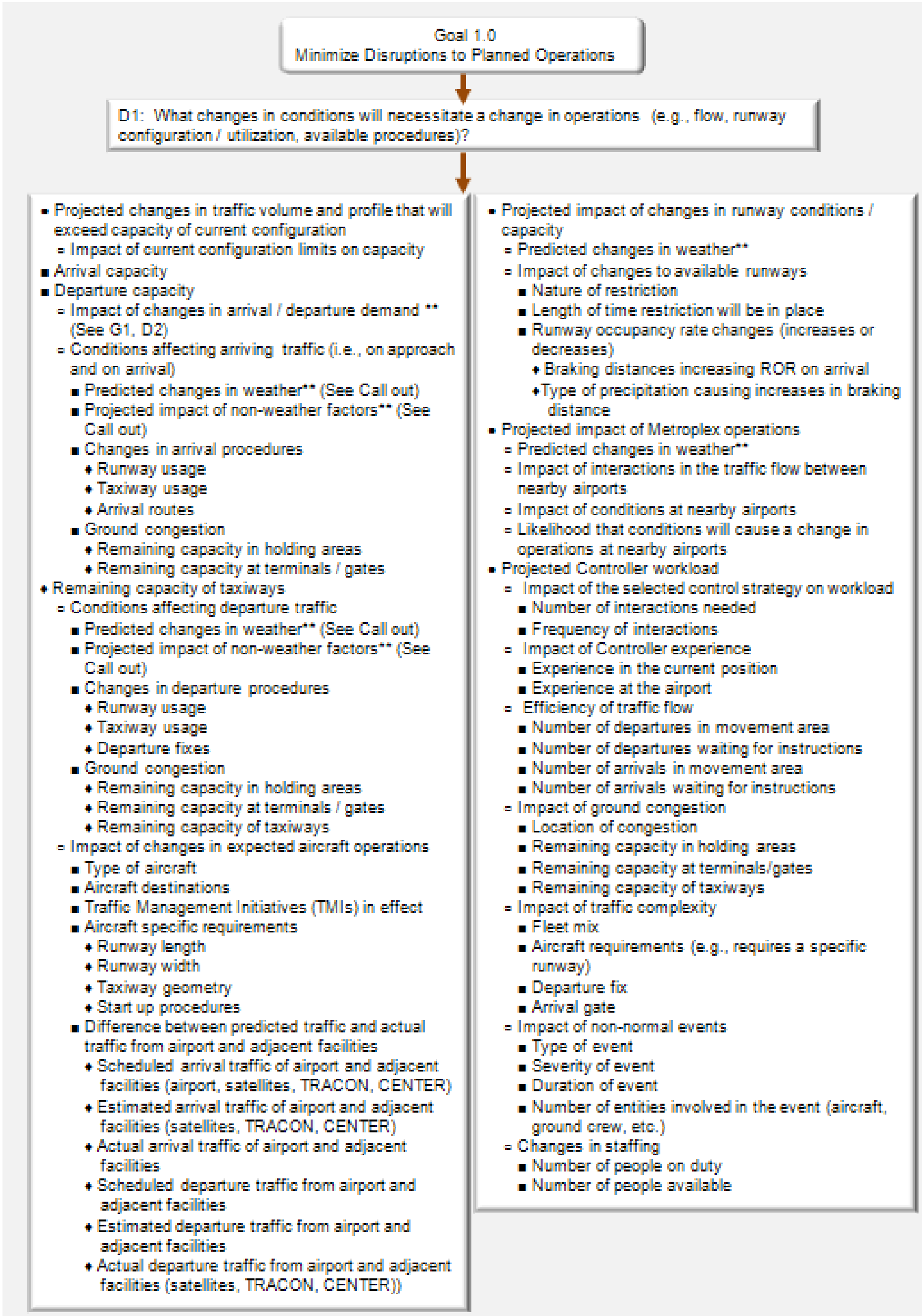

Figure 9. Goal 1, Decision 1 – Determining if a change is necessary.

(** Reference Figures 15 & 16 for Weather and Non-Weather intruding event callouts.)

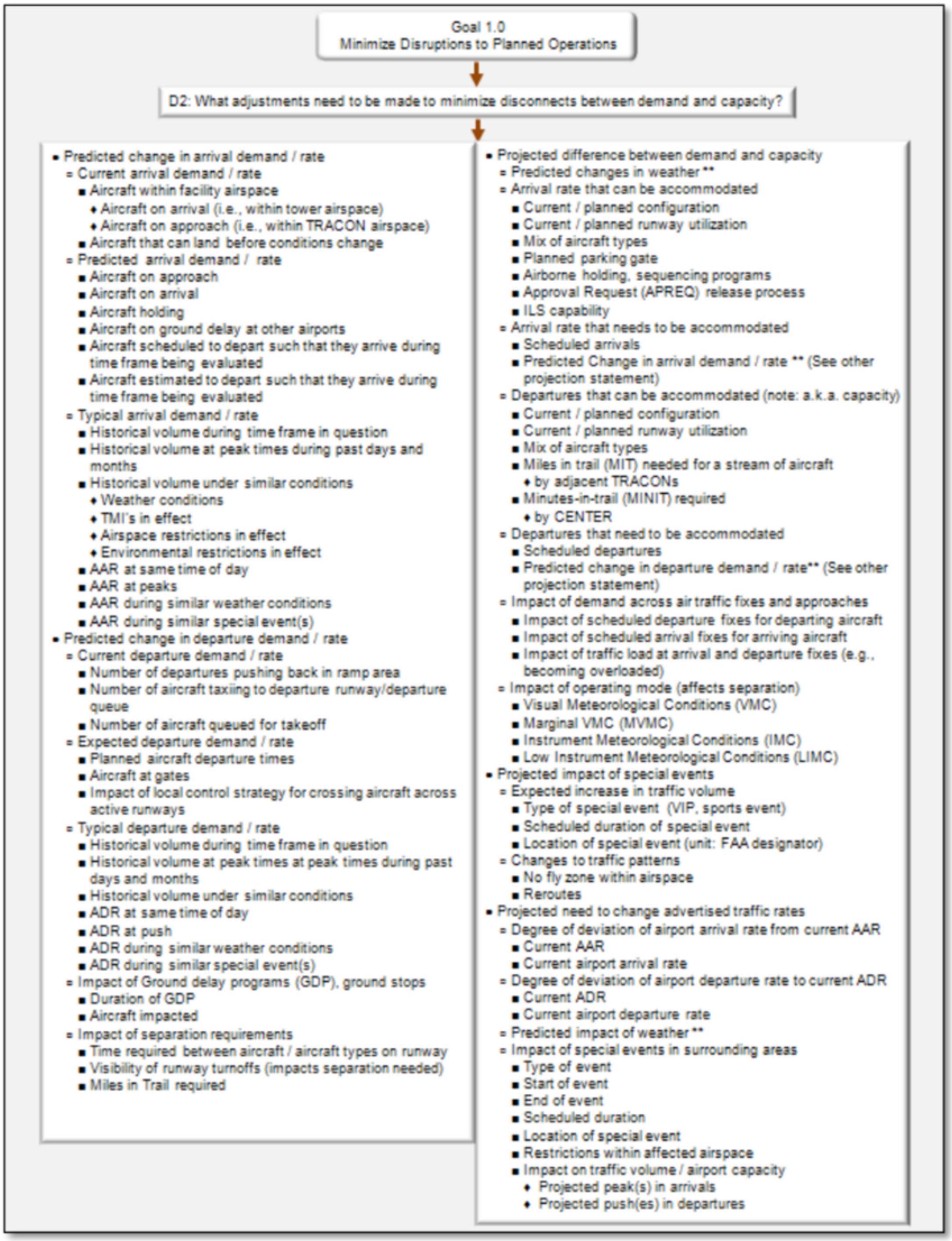

Figure 10. Goal 1, Decision 2 – Identifying the adjustments required.

(** Reference Figures 15 & 16 for Weather and Non-Weather intruding event callouts.)

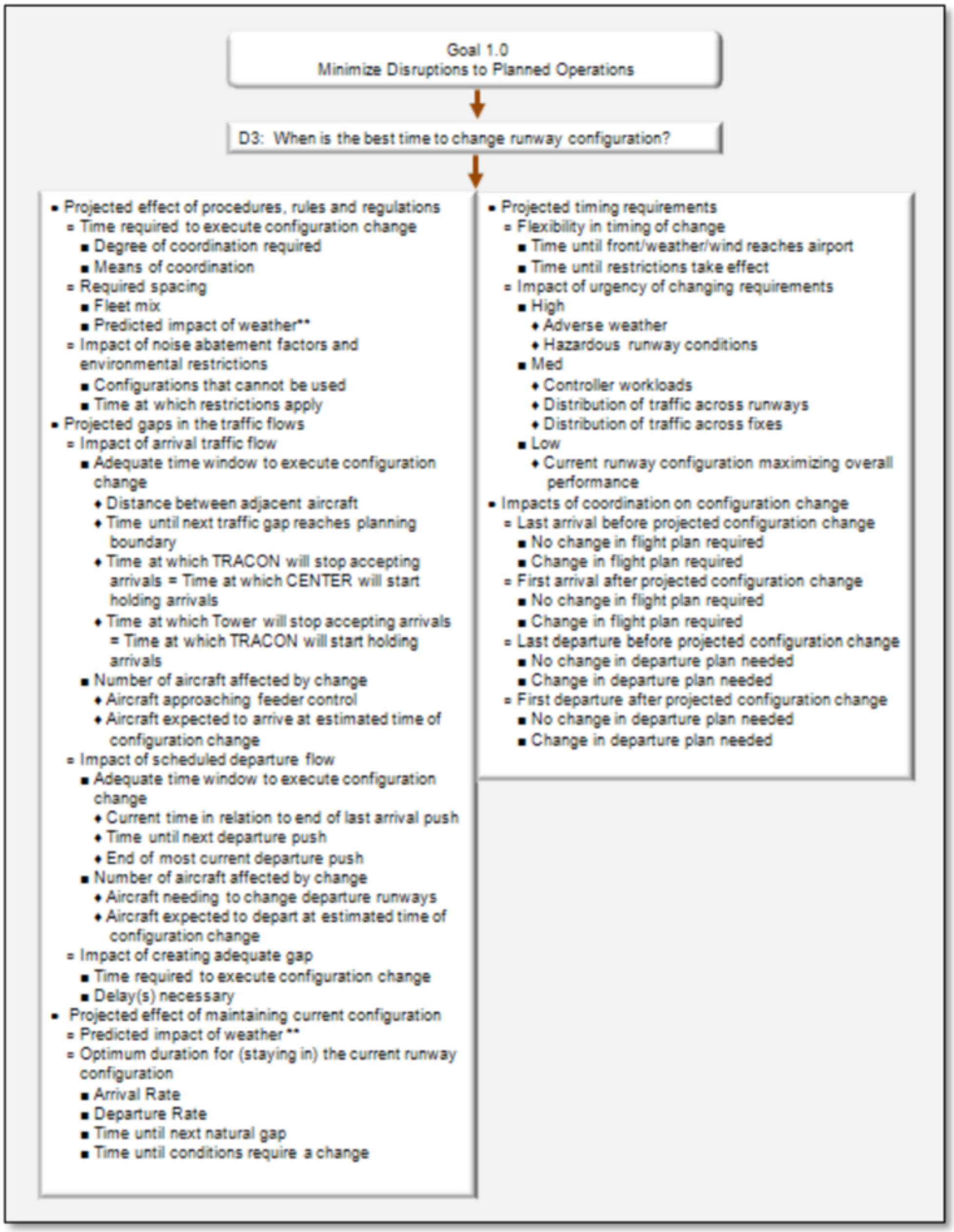

Figure 11. Goal 1, Decision 3 – Determining when to make an adjustment.

(** Reference Figures 15 & 16 for Weather and Non-Weather intruding event callouts.)

Goal 2.0
Effectively Distribute Demand Across Resources

D1: How can traffic be distributed across the airport and airport resources to meet capacity requirements?

- Projected runway load
  - Predicted impact of weather **
  - Impact of runway utilization on traffic load
    - Capacity of runways in use / available
    - Departure runways
    - Arrival runways
  - Impact of Departures
    - Current departure queue
    - Scheduled departures
    - Fleet mix of departures
    - Departure spacing required
    - Scheduled departures route
    - Current spacing between aircraft departing
  - Impact of ground congestion
    - Capacity in holding areas/ Number of aircraft in holding areas
    - Capacity at terminals / gates / Number of aircraft at terminal
    - Capacity of taxiways / Number on taxiways
    - Proximity of arrival runway / taxiway to gate
    - Proximity of departure runway / taxiway to gate
  - Impact of arrivals
    - Arrivals currently within airspace
    - Scheduled arrivals
    - Arrival spacing
    - Assigned approach
    - Assigned fix
    - Fix ID
    - Fleet mix of arrivals
    - Departure spacing
  - Impact of Arrival / Departure dependencies
    - Runway crossings
    - Parallel operations
    - Dual use operations
    - Airport operating point / airport configuration
- Projected effect of airline operations on airport traffic
  - Airline gate availability
    - Total gates available
    - Gates occupied
    - Gates needed to accommodate arrival / departure demand
  - Impact of unmet arrival demand (i.e., delayed arrivals) on air carrier departure demand
    - Arriving aircraft and crew which make up departures
    - Arriving passengers with departing connections
- Projected effect of air traffic across fixes and approaches
  - Impact of scheduled departure fixes for departing aircraft
    - Rate at which aircraft need to depart via each fix to satisfy demand
      - Number of aircraft scheduled to depart via each fix
      - Separation requirements at the fix
    - Rate of departures that can be accommodated at each fix
    - Availability of alternate fixes
  - Impact of scheduled arrival gate for arriving aircraft
    - Rate at which aircraft need to arrive via each gate to satisfy demand
      - Number of aircraft scheduled to arrive via each gate
      - Separation requirements for each gate
    - Rate that can be accommodated at each gate
    - Availability of alternate arrival gates
- Projected effect of air traffic across fixes and approaches (cont)
  - Impact of airport configuration
    - AAR / ADR
    - Arrival runways available
    - Departure runways available
  - Impact of fleet mix
    - Speed differentials
    - Miles in trail requirements
    - Other aircraft specific considerations
- Projected ability to change flight plan parameters to equalize traffic
  - Impact of currently rerouted arrivals
    - Arrival spacing
    - Assigned approach
    - Assigned fix
    - Fix ID
    - Fleet mix
    - Departure spacing
  - Impact of currently rerouted departures
    - Fleet mix
    - Departure spacing
    - Scheduled departures route
    - Current spacing between aircraft departing
  - Impact of traffic spacing on load
    - MIT
    - Fix holding capacity
  - Impact of availability of fixes and approaches
    - Predicted impact of weather**
    - Fixes not currently available for use
    - Approaches not currently available for use
    - Departure routes not currently available for use
    - Limitations based on restrictions / procedures
  - Impact of airport configuration
    - AAR / ADR
    - Arrival runways available
    - Departure runways available
- Predicted ability to balance runways
  - Impact of current / planned arrivals and departures
    - Time of arrivals / departures
    - Type of arrivals / departures
    - Location of arrivals / departures
    - Ease of getting to departure runway
    - Ease of getting from arrival runway to gate
    - TMIs in effect
      - MIT required
      - MINIT required
      - GDP, ground stops
  - Impact of direction of wind
    - Configurations that allows takeoff into the wind
    - Runways that will allow takeoff into the wind
    - Crosswinds created on potential runway
      - Speed of wind
      - Direction of wind
      - Wind alignment with runway
    - Tailwind created on potential runway
      - Speed of wind
      - Direction of wind
      - Wind alignment with runway
  - Impact of runway assignment policy
    - Single use or dual use
    - Space between runways and associated policy
    - Types of aircraft
- Impact of Metroplex Operations

Figure 12. Goal 2 – Determining how to meet capacity.

(** Reference Figures 15 & 16 for Weather and Non-Weather intruding event callouts.)

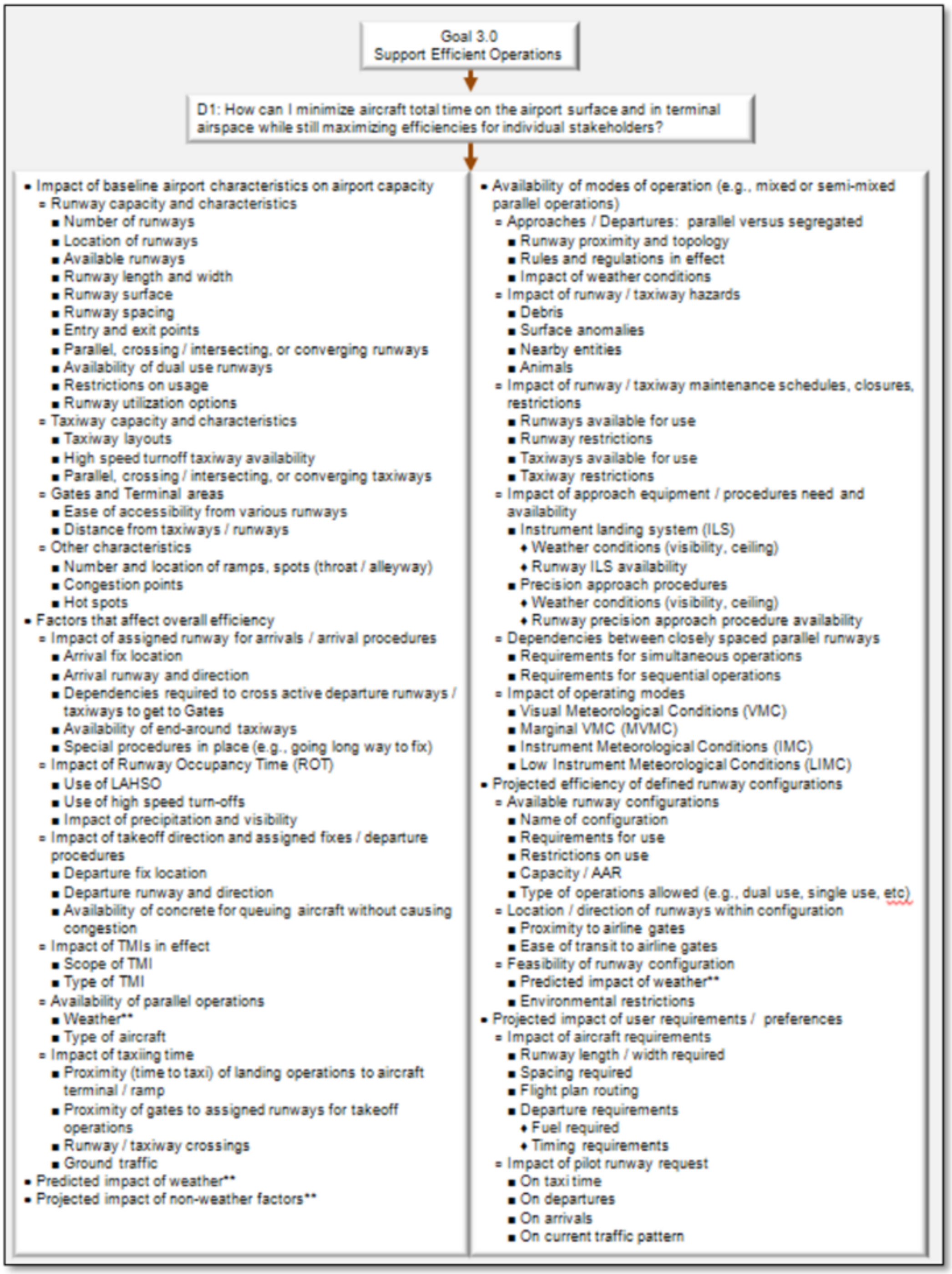

Figure 13. Goal 3 – Maximizing efficiencies.

(** Reference Figures 15 & 16 for Weather and Non-Weather intruding event callouts.)

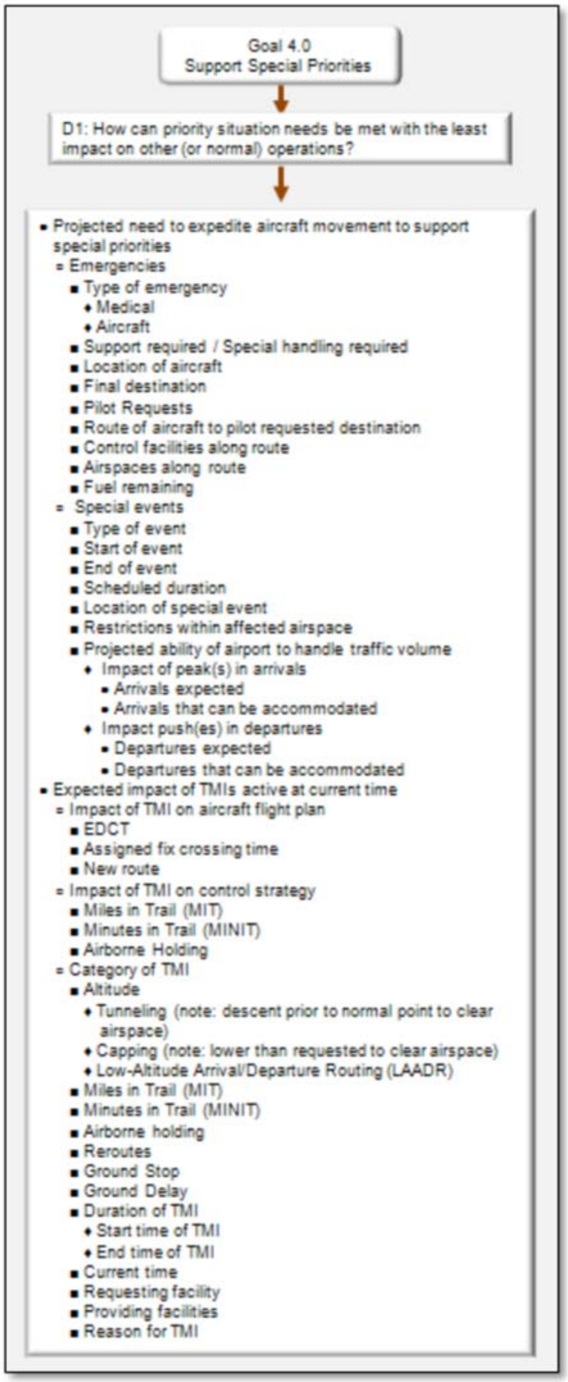

Figure 14. Goal 4 – Priority event management.

- Predicted impact of weather
  - Impact of impending weather events
    - Time weather will affect airport / TRACON
      - Current location
      - Distance from airport / boundary area
      - Direction of movement
      - Rate of movement
      - Time remaining until weather impact is felt
    - Length of time weather will affect airport
    - Type of weather event
      - Increases in turbulence
      - Lightening
      - Precipitation
      - Increases in wind
      - Reduction in visibility
    - Pilot reports
    - Follow up needed after event to make sure runways safe
  - Impact of changes in wind speed
    - Current
    - Rate of change
    - Predicted
    - Relation to threshold values
  - Impact of changes in wind direction
    - Current
    - Rate of change
    - Predicted
    - Direction in relation to orientation of active runways
  - Impact of presence of wind shear
    - Location
    - Severity
    - Duration
  - Impact of presence of microbursts
    - Location
    - Severity
    - Duration
  - Impact of changes in visibility
    - Type of visibility affected
      - Slant visibility / threshold
      - Runway visual range / threshold
      - IFR conditions / threshold
      - VFR conditions / threshold
      - Ceiling / threshold
    - Rate visibility is decreasing / increasing
    - Category of meteorological conditions created
      - VMC (Visual Meteorological Conditions) / Low VMC
      - IMC (Instrument Meteorological Conditions) / Low IMC
  - Impact of changes in precipitation
    - Type of precipitation
      - Rain
      - Snow
      - Hail
    - Accumulation
    - Duration
  - Impact of changes in temperature
    - Temperature increasing / decreasing
    - Rate of change
    - Time Thresholds reached (e.g., time freezing begins)

Figure 15. Weather event management.

- Projected impact of non-weather factors
  - Impact of natural and man-made disaster
  - Impact of changes in restricted airspace
    - Nature of restriction
    - Length of time restriction will be in place
    - Special use Airspace (SUA) adjacent to or near airport
  - Impact of changes in available runways
    - Nature of closure
    - Length of time closure will be in place
  - Impact of requests from NAS (e.g., Center)
    - Preferred routing (e.g. National Playbook call)
  - Special Priorities
    - Emergencies
      - Type of emergency
      - Support required / Special handling required
    - VIP movement / traffic
      - Type of event
      - scheduled duration
      - location of special event
      - restrictions within affected airspace
  - Impact of equipment status
    - Scheduled Maintenance
    - Unexpected outages
    - restrictions on approach types
  - Impact of noise abatement factors and environmental restrictions
    - Runway configuration rotation rules
      - e.g., Heathrow direction flipped daily at 3pm weather permitting
    - Arrival / departure windows
    - Existence of preferred runway configurations
    - Runway use rules
      - e.g., Heathrow northern runway can't be used for take-offs in an easterly direction
  - Impact of Instrument Flight Rules (IFR) restrictions or procedures
- Projected impact of Traffic Management Initiative (TMI)
  - Nature of TMI
    - TMI ID
    - Type of TMI
    - TMI start / end time
    - Time until TMI starts / end
      - Current Time
      - Planned duration of TMI
    - Time remaining on TMI
    - Scope of TMI (note: tier based or distance based)
      - TMIs affecting traffic in neighboring TRACONS
      - Requesting facility
  - Impact of TMI on arriving / departing aircraft
    - Changes required to arrival / departure sequencing
    - Location of aircraft
    - Space available for delays / re-sequencing
    - Congestion caused by aircraft affected by TMI
    - Restrictions on traffic flow to TRACON
      - Volume out gates
      - MIT required

Figure 16. Non-weather event management.

Function Analysis

The Function Analysis (FA) identifies the functions that must be performed to support the traffic management personnel in making a decision and accomplishing a goal. Specifically, a function is defined as an activity that must be performed by the system, the individual, or a combination of the two to partially meet a goal. Functions are made up of tasks and operations. Tasks are defined as actions performed by an individual to help accomplish a function, while an operation is defined as an action performed by the system to help accomplish a function. As the purpose of the FA is to provide input into the general design specifications for user interfaces, this FA focuses on higher order functions and tasks/operations rather than the specific series of sequential GUI interactions that must be performed to actually carry out the activity. Additionally, this FA does not differentiate between tasks and operations since the allocation of tasks/operations is beyond the scope of this analysis. Thus, the FA captures the actions TMCs need to carry out in order to make decisions and achieve their goals (Table 3).

Table 3. SORM Functional Analysis.

Goal	Decision	Function	Task
1.0 Minimize Disruptions to Planned Operations	D1: What changes in conditions will necessitate a change in operations?	Determine if a change in configuration is needed	Review capacity with current configuration / utilization
			Evaluate weather conditions for impact on current operations (e.g., flow / configuration / utilization)
			Evaluate changes in arrival and departure demand
			Evaluate if any changes in airspace restriction impact what configuration is needed
			Determine if any new TMIs impact configuration / utilization
			Determine if any environmental restrictions impact what configuration is needed
			Determine if any changes have occurred in runway availability
			Consider any limitations imposed by personnel availability / workload
			Determine if capacity of current configuration meets demand
			Coordinate with nearby airports to see if a change is impending for them
			Coordinate potential changes with affected stakeholders
	D2: What adjustments need to be made to minimize disconnects between demand and capacity?	Establish / Update AAR / ADR	Attend daily ATCSCC teleconference with ARTCC, TRACON, and other representatives
			Determine what weather impact will be
			Review national and local TMI
			Specify the planned airport arrival and departure capacities (for the airport or in the future for each runway)
			Plan schedule of airport configurations to advise on configuration decisions
			Monitor pulse of air traffic system and report to ATCSCC / Traffic management specialist ("Command center")
			Coordinate with supervisor to change staffing as necessary
	D3: When is the best time to change runway configuration?	Select runway configuration	Specify which runways are primarily used for arrivals and which runways are primarily used for departures
			Define how arrivals and departures will be using the runways available in selected configuration
			Describe the primary plan for arrival and departure taxi routing
			Coordinate with TRACON, AOC, and ATCSCC as necessary
			Coordinate with TRACON supervisor to indicate new runway configuration and change time
			Coordinate with one or more major stakeholders either during the decision-making process, or to inform them when the decision has been made
			Accept or reject runway configuration change recommendation (if initiated externally)

Table 3. SORM Functional Analysis (continued).

		Determine runway configuration change time	Look for coincident gaps between arrivals at each of the arrival fixes
			Select last arrival across each arrival fix before runway configuration change (e.g., TRACON supervisor will tell the tower who the last arrival will be for the old configuration and who the last departure will be for the old configuration)
			Coordinate airspace change
2.0 Effectively Distribute Demand Across Resources	How can traffic be distributed across the airport and airport resources to meet capacity requirements?	Distribute traffic across the airport	Distribute arrival and departure traffic across active runways in conjunction with effective scheduling of traffic on those runways
			Set departure traffic flow to the runways
			Ensure that the staging of the aircraft is correct and meets ground times (release time)
			Consider airport / metroplex throughput, delays, efficiency, taxi path, forecasted traffic demand, wind forecast, planned TMIs
		Balance traffic across fixes	Monitor operations to determine if traffic is queuing up at a particular fix
			Determine if traffic can be rerouted to other fixes
			If so, coordinate changes with impacted stakeholders.
3.0 Support Efficient Operations	How can I minimize total time on the airport surface and in terminal airspace while still maximizing efficiencies for individual stakeholders?	Minimize total time in terminal control	Understand NAS priorities / objectives
			Determine how best to use airport resources to minimize time in terminal control
		Maximize efficiency for individual stakeholders	Assign arrival / departures to support stakeholder needs
			Approve special requests as able
4.0 Support Special Priorities	How can high priority needs be met with the least impact on other (or normal) operations?	Determine impact of special events on operations	Evaluate impact of special events on operations
			Coordinate any special instructions for handling special event
			Determine type of support needed
			Coordinate with impacted stakeholders to support priority aircraft

Information Requirements

By integrating the preceding analyses, the system requirements for the SORM tools were derived to clearly define what information the users need in order to utilize this tool. These requirements are documented per goal in **Error! Reference source not found.** through Table 11.

Table 4. Information requirements supporting Goal 1, Decision 1.

The system shall enable presentation of details related to a given configuration, including:
Configuration ID (if such an ID exists)
Arrival runways available in given configuration
Departure runways available in given configuration
Runway restrictions impacting given configuration
Typical acceptance rate for given configuration
Maximum acceptance capacity for given configuration
Typical departure rate for given configuration
Maximum departure capacity for given configuration
The system shall support the user in making assessments of capacity based on current conditions, including providing the following information:
Typical acceptance rate for given configuration and conditions
Maximum arrival capacity for given configuration and conditions
Typical departure rate for given configuration and conditions
Maximum departure capacity for given configuration and conditions
The system shall help the user identify when demand is projected to exceed capacity based on:
Current traffic volume
Predicted traffic volume
Current configuration
Current conditions
Changes in arrival procedures, including changes in runway usage, taxiway usage, and arrival routes
Changes in departure procedures, e.g., changes in runway usage, taxiway usage, and departure fixes
The system shall enable presentation of information related to ground congestion, including:
Remaining capacity in holding areas
Remaining capacity at terminals / gates
Remaining capacity of taxiways
The system shall help the user identify changes in aircraft operations that could impact runway configuration, including changes in:
Types of aircraft expected
Aircraft destinations
Aircraft specific requirements / restrictions, including runway length, runway width, taxiway geometry, aircraft start up procedures
The system shall support the user in assessing differences in scheduled / estimated / actual traffic flow, including:
Scheduled arrival traffic of airport and adjacent facilities (airport, satellites, TRACON, CENTER)
Estimated arrival traffic of airport and adjacent facilities (satellites, TRACON, CENTER)
Actual arrival traffic of airport and adjacent facilities
Scheduled departure traffic from airport and adjacent facilities
Estimated departure traffic from airport and adjacent facilities
Actual departure traffic from airport and adjacent facilities (satellites, TRACON, CENTER)
The system shall support the user in assessing how changes in runway conditions / capacity will impact capacity for a given configuration. Factors to consider include:
Nature of restriction
Length of time restriction will be in place
Runway occupancy rate changes (increase or decrease)
Braking distances increasing ROR on arrival
Type of precipitation causing increases in braking distance

Table 5. Information requirements supporting Goal 1, Decision 2.

The system shall enable the user to view information related to current, projected, and historical arrival rates including:
Aircraft on arrival
Aircraft on approach
Aircraft that can land before a specified time and/or event
Aircraft holding
Aircraft on ground delay at other airports
Aircraft scheduled / estimated to depart other facilities such that they will and at specified airport within time frame under consideration
Historical arrival / demand rates
Historical volume during time frame in question
Historical volume at peak times during past days and months
Historical volume under similar conditions (e.g., weather conditions, similar TMI's in effect, similar airspace / environmental restrictions)
Airport Arrival Rate at same time of day
Airport Arrival Rate at peaks
Airport Arrival Rate during similar weather conditions
Airport Arrival Rate during similar special event(s)
The system shall enable the user to view information related to current, projected, and historical departure rates including:
Number of departures pushing back in ramp area
Number of aircraft taxiing to departure runway/departure queue
Number of aircraft queued for takeoff
Planned aircraft departure times
Aircraft at gates
Impact of local control strategy for crossing aircraft across active runways
Historical volume during time frame in question
Historical volume at peak times at peak times during past days and months
Historical volume under similar conditions
Airport Departure Rate at same time of day
Airport Departure Rate at push
Airport Departure Rate during similar weather conditions
Airport Departure Rate during similar special events
Ground delay programs (GDP), ground stops
Duration of GDP
Aircraft impacted
Impact of separation requirements on departure rates, including
Time required between aircraft / aircraft types on runway
Visibility of runway turnoffs as it impacts separation needed
Miles in Trail required

Table 5. Information requirements supporting Goal 1, Decision 2 (continued).

The system shall support the user in determining differences between demand and capacity by presenting the following information:
Arrival rate that can be accommodated in consideration of:
Current / planned configuration
Current / planned runway utilization
Mix of aircraft types
Planned parking gate
Airborne holding, sequencing programs
Approval Request (APREQ) release process
ILS capability
Arrival rate that needs to be accommodated
Scheduled arrivals
Predicted arrivals
Departures that can be accommodated
Miles in trail (MIT) needed for a stream of aircraft
Minutes-in-trail (MINIT) required
Departures that need to be accommodated
Scheduled departures
Predicted change in departure demand / rate
Demand across air traffic fixes and approaches
Scheduled departure fixes for departing aircraft
Scheduled arrival fixes for arriving aircraft
Traffic load at arrival and departure fixes
Impact of operating mode as it affects separation requirements, including
Visual Meteorological Conditions (VMC)
Marginal VMC (MVMC)
Instrument Meteorological Conditions (IMC)
Low Instrument Meteorological Conditions (LIMC)
The system shall provide information about special events that could impact demand.
Type of event
Start day/time of event
End day/time of event
Duration of the event
Location of event
Restrictions within affected airspace
Impact on traffic volume and airport capacity
Projected peaks in arrivals - timing, volume, and rate
Projected pushes in departures - timing, volume, and rate
Can change be accommodated by current AAR/ADR
If not, how much difference between demand and current AAR/ADR

Table 6. Information requirements supporting Goal 1, Decision 3.

The system shall support the user in determining options for when to change runway configuration by presenting:
Time required to execute configuration change
Required spacing
Noise abatement factors and environmental restrictions that impact possible configurations
Start / Stop / Duration of restrictions
The system shall identify potential gaps in traffic flows for runway configuration changes in consideration of:
Gaps in arrival traffic
Distance between adjacent aircraft
Time until next traffic gap reaches planning boundary
Time at which TRACON will stop accepting arrivals
Time at which Tower will stop accepting arrivals
Number of arriving aircraft affected by the change:
Aircraft approaching feeder control
Aircraft expected to arrive at the estimated time of configuration change
Gaps in departure flow
Current time in relation to end of last arrival push
Time until next departure push
End of most current departure push
Number of departing aircraft affected by change:
Aircraft needing to change departure runways
Aircraft expected to depart at estimated time of configuration change
Time required to execute configuration change
The system shall support the user's determination of the optimum time for changing runway configuration by providing:
Delays that would be necessary to enable configuration change
Arrival Rate
Departure Rate
Time until next natural gap
Time until conditions require a change
Time until front / weather / wind reaches airport
Time until restrictions take effect
Severity of conditions forcing the runway configuration change
The system shall support operators' coordination with other agents associated with runway configuration change by providing:
Last arrival before projected configuration change
If a change in flight plan is required, and if so, what change
First arrival after projected configuration change
If a change in flight plan is required, and if so, what change
Last departure before projected configuration change
If a change in departure plan is required, and if so, what change
First departure after projected configuration change
If a change in departure plan is required, and if so, what change

Table 7. Information requirements supporting Goal 2.

The system shall support the user in assessing runway load by considering:
Capacity of runways in use / available
Departure runways
Arrival runways
Runway crossings
Parallel operations
Dual use operations
Arrivals
Arrivals currently within airspace
Scheduled arrivals
Rate at which aircraft need to arrive via each gate to satisfy demand
Number of aircraft scheduled to arrive via each gate
Separation requirements for each gate
Rate that can be accommodated at each gate
Availability of alternate arrival gates
Arrival spacing
Assigned approach
Assigned fix
Fix ID
Fleet mix of arrivals
Speed differentials
Miles in trail requirements
Other aircraft specific considerations
Departures
Current departure queue
Scheduled departures
Fleet mix of departures
Departure spacing required
Scheduled departure routes
Current spacing between aircraft departing
The system shall support the user in assessing the impact of airport operations on ability to change runway distribution by providing information on:
Capacity remaining in holding areas
Number of aircraft in holding areas
Capacity remaining at terminals
Number of aircraft at terminal
Capacity remaining for taxiways
Number of aircraft on taxiways
Proximity of arrival runway / taxiway to gate
Proximity of departure runway / taxiway to gate

Table 7. Information requirements supporting Goal 2 (continued).

The system shall support the user in assessing the feasibility of modifying flight plan parameters to balance runway distribution by providing:
Current runway load
Ability to modify arrivals
Arrival spacing
Assigned approach
Assigned fix
Fix ID
Fleet mix
Departure spacing
Ability to modify departures
Fleet mix
Departure spacing
Scheduled departures route
Current spacing between aircraft departing
Rate at which aircraft need to depart via each fix to satisfy demand
Number of aircraft scheduled to depart via each fix
Separation requirements at the fix
Rate of departures that can be accommodated at each fix
Availability of alternate fixes
Miles in Trail (MIT)
Minutes in Trail (MINIT)
Ground Delay Programs in effect / Ground Stops
Fix holding capacity
Fixes not currently available for use
Approaches not currently available for use
Departure routes not currently available for use
Limitations based on restrictions / procedures
AAR / ADR
Arrival runways available
Departure runways available

Table 7. Information requirements supporting Goal 2 (continued).

The system shall support the user in identifying options for balancing runway usage by considering:
Time of arrivals / departures
Type of arrivals / departures
Location of arrivals / departures
Ease of getting to departure runway
Ease of getting from arrival runway to gate
Factors related to wind, including:
Configurations that allow take-off into the wind
Runways that will allow take-off into the wind
Crosswinds created on potential runway
Tailwind created on potential runway
Speed of wind
Direction of wind
Wind alignment with runway
Single use or dual use of runway
Distance between runways and associated policy for simultaneous use
Types of aircraft
TMIs in effect, including:
Miles in Trail (MIT)
Minutes in Trail MINIT
Ground Delay Programs / Ground Stops

Table 8. Information requirements supporting Goal 3.

The system shall provide the user information related to baseline airport characteristics, including:
Runway capacity and characteristics, including:
Number of runways
Location of runways
Available runways
Runway length and width
Runway surface
Runway spacing
Entry and exit points
Parallel, crossing / intersecting, or converging runways
Availability of dual use runways
Restrictions on usage
Runway utilization options
Taxiway capacity and characteristics, including:
Taxiway layouts
High speed turnoff taxiway availability
Parallel, crossing / intersecting, or converging taxiways
Gates and Terminal areas, including
Ease of accessibility from various runways
Distance from taxiways / runways
Other characteristics, including
Number and location of ramps, spots (throat / alleyway)
Congestion points
Hot spots

Table 8. Information requirements supporting Goal 3 (continued).

The system shall provide the user information related to efficiency of the current runway configuration and usage policy, including:
Arrivals
Arrival rate supported
Arrival fix location
Arrival runway and direction
Dependencies required to cross active departure runways / taxiways to get to gates
Availability of end-around taxiways
Special procedures in place (e.g., going long way to fix)
Runway Occupancy Time (ROT)
Availability of LAHSO
Availability of high speed turn-offs
Limitations due to precipitation and visibility
Impact of takeoff direction and assigned fixes / departure procedures
Departure fix location
Departure runway and direction
Availability of concrete for queuing aircraft without causing congestion
Limitations due to TMIs in effect
Time TMI Starts
Time TMI Ends
Duration of TMI
Availability of parallel operations
Limitations due to weather
Limitations based on aircraft type
Impact of taxiing time
Proximity (time to taxi) of landing operations to aircraft terminal / ramp
Proximity of gates to assigned runways for takeoff operations
Runway / taxiway crossings
Ground traffic

Table 8. Information requirements supporting Goal 3 (continued).

The system shall provide the user information related to efficiency of potential runway configuration and usage policy, including consideration of the following:
Available runway configurations
Name of configuration
Requirements for use
Restrictions on use
Capacity / AAR
Type of operations allowed (e.g., dual use, single use, etc.)
Location / direction of runways within configuration
Proximity to airline gates
Ease of transit to airline gates
Feasibility of runway configuration
Limitations due to weather
Limitations due to environmental restrictions
Approaches / Departures available
Runway proximity and topology
Rules and regulations in effect
Limitations due to weather conditions
Runways / Taxiways available
Runways available for use
Runway restrictions
Taxiways available for use
Taxiway restrictions
Presence of runway / taxiway hazards
Approach equipment needed / available
Instrument landing system (ILS)
Precision approach procedures
Dependencies between closely-spaced parallel runways
Requirements for simultaneous operations
Requirements for sequential operations
Available operating modes
Visual Meteorological Conditions (VMC)
Marginal VMC (MVMC)
Instrument Meteorological Conditions (IMC)
Low Instrument Meteorological Conditions (LIMC)

Table 9. Information requirements supporting Goal 4.

The system shall provide the user with information related to emergencies, including:
Type of emergency
Support required / Special handling required
Location of aircraft
Final destination
Pilot Requests
Route and destination requested by pilot
Control facilities along route
Airspaces along route
Fuel remaining
The system shall provide the user with information related to special events, including the following:
Type of event
Start of event
End of event
Scheduled duration
Location of special event
Restrictions within affected airspace
Discrepancies between capacity and demand
Arrivals expected
Arrivals that can be accommodated
Timing of peaks
Departures expected
Departures that can be accommodated
Impact pushes in departures
The system shall provide the users with information regarding Traffic Management Initiatives (TMIs), including:
Reason for TMI
Start time of TMI
End time of TMI
Current time
Duration of TMI
Flights affected by TMI
Miles in Trail (MIT)
Minutes in Trail (MINIT)
Airborne Holding
Altitude
Tunneling (descent prior to normal point to clear airspace)
Capping (lower than requested to clear airspace)
Low-Altitude Arrival/Departure Routing (LAADR)
Reroutes
Ground Stop
Ground Delay
Requesting facility
Providing facilities

Table 10. Information requirements supporting weather event management.

The system shall provide both map and text based weather data
The system shall provide weather information to support prediction of impacts of weather conditions / events on runway configuration by enabling the presentation of the following information regarding weather events:
Time weather event will affect the airport / TRACON area
Current location of weather events
Distance of weather event from airport / boundary area
Direction of movement of weather event
Rate of movement of the weather event
Time remaining until the weather event impacts airport / TRACON area
Length of time the weather will affect the airport
Type of weather event
Presence / severity of turbulence (e.g., altitudes affected)
Presence / severity of lightning activity
Presence / severity of hail
Pilot Reports of weather impacts
Runway status - any damage or closures required to make safe after the storm.
Wind Information
Current wind speed
Rate of change of wind speed
Predicted wind speed
Current wind direction
Rate of change in wind direction
Predicted wind direction
Severity / Duration / Location of wind shear
Severity / Duration / Location of microbursts
Visibility Information
Slant visibility / threshold / rate of change / direction of change
Runway visual range / threshold / rate of change / direction of change
IFR conditions / threshold / rate of change / direction of change
VFR conditions / threshold / rate of change / direction of change
Ceiling / threshold / rate of change / direction of change
Meteorological category based on current meteorological conditions (e.g., VMC, IMC, etc.).
Current condition
Rate of change / direction of change
Predicted future condition
Time until future condition becomes current condition
Precipitation Type (e.g., rain, snow, sleet, hail, etc.), Severity, Accumulation, Duration, Rate,

Table 11. Information requirements supporting other priority event management.

The system shall present the following information:
Restricted airspace
Nature of restriction
Length of time restriction will be in place
Special use airspace (SUA) adjacent to or near airport
Arrival restrictions
Departure Restrictions
Runways
Nature of closure
Length of time closure will be in place
Requests from NAS
Emergencies
Type of emergency
Support required / Special handling required
VIP movement / traffic
Type of event
Scheduled duration
Location of special event
Restrictions within affected airspace
Equipment status
Current status
Scheduled Maintenance
Unexpected outages
Restrictions on approach types
Noise abatement factors and environmental restrictions
Runway configuration rotation rules
Arrival / departure windows
Existence of preferred runway configurations
Runway use rules
Instrument Flight Rules (IFR) departure restrictions or procedures
The system shall present information related to Traffic Management Initiatives, including:
TMI ID
Type of TMI
TMI start / end time
Time until TMI starts / end
Current Time
Planned duration of TMI
Time remaining on TMI
TMIs affecting traffic in neighboring TRACONS
Changes required to arrival / departure sequencing
Location of aircraft
Space available for delays / re-sequencing
Congestion caused by aircraft affected by TMI
Restrictions on traffic flow to TRACON
Volume out gates
MIT required

Graphical User Interface Development

The second phase of the SAOD process combines information from the analyses conducted during the requirements phase with SA-oriented design principles and established human factors and design guidelines to create user-centered designs for SORM (Figure 17). The SAOD process includes 50 design principles covering all aspects of system designs. These principles are based on over 50 years of research and address areas such as confidence and uncertainty in decision making, dealing with complexity, designing alarms, integrating humans and automation, supporting multiple and distributed operators, and supporting team SA (Figure 18). These principles incorporate the best research to provide prescriptive rules for designing systems that support a high level of operator SA and performance, thereby providing an effective framework from which to develop the SORM tool.

The SORM tool concepts developed during this effort included four designed views (Current Ops, Demand, Configuration, and Balance Traffic) and two configurable tile panes (one on each side of the display). The tile panes and the designed views are briefly described in subsequent sections, and Appendix A details the interface control features for each page. Full descriptions can be found in the Preliminary GUI Functionality Description (Jones, Lenox & Onal, 2012).

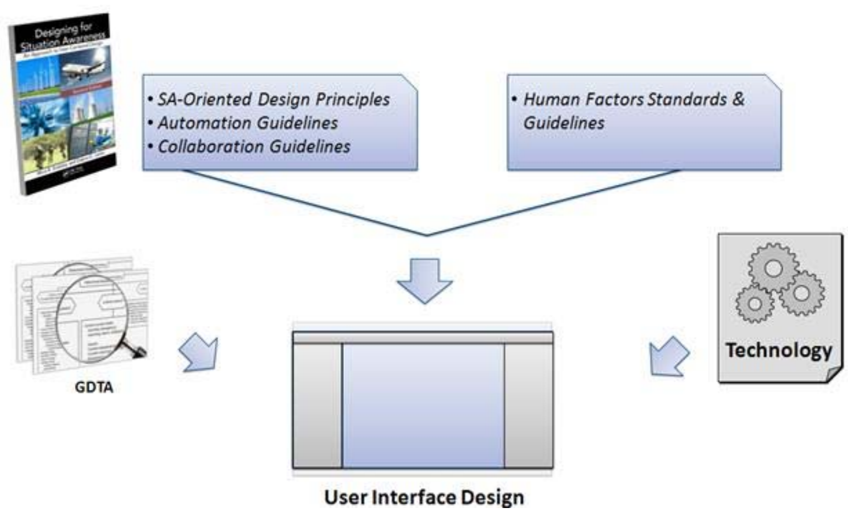

Figure 17. Inputs to the GUI design.

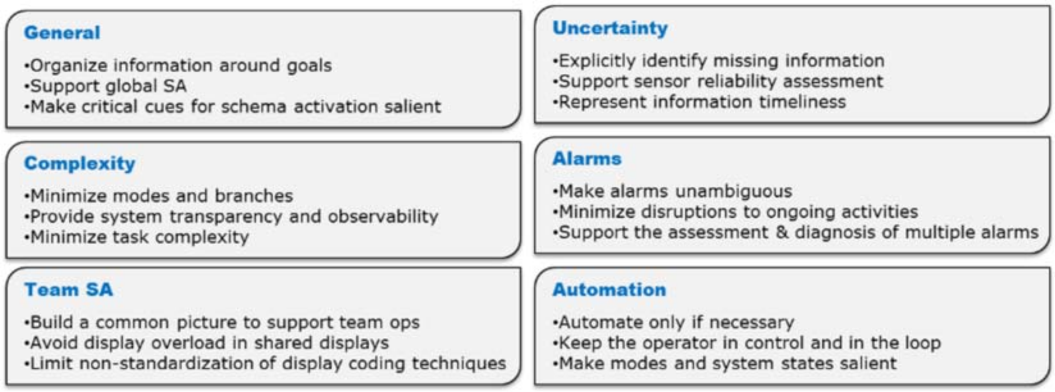

Figure 18. Principles for supporting SA through design.

Tile Panes

Two tile panes, one on each side of the display, can be configured as needed to support global SA while the TMC is working on detailed information in the main area of the display. These tile panes are turned on and off using mini buttons in the upper left hand corner of the display. The tiles in this version of the SORM GUI are shown in Figure 19, and include the following:

- ***Current configuration:*** displays information about the current configuration, including a visual representation of the way the runways are being used (e.g., arrivals or departures), current airport acceptance rate (AAR), current airport departure rate (ADR), and time until the next planned configuration change.
- ***Next configuration:*** displays information about the next planned configuration, including the time the configuration will change and a visual representation of the way the runways will be used (e.g., exclusively for arrivals or departures, or dual use).
- ***Weather:*** provides an overview of the weather situation by allowing a view into relevant weather information sources (e.g., a radar loop showing convective weather relevant to the airport).
- ***Arrivals:*** provides information regarding the current arrival rate, the projected arrival rate, and the maximum arrivals that can be accepted.
- ***Departures:*** provides information regarding the current departure rate, the projected departure rate, and the number of departures that can be accommodated given the current configuration plan.

- ***Traffic Management Initiative (TMI):*** shows a list of active traffic management initiatives, along with the time the initiative became active and the expected time for it to end.
- ***Fix Status:*** displays the status of the fixes; i.e., which are open, or closed. On this view, the user can select display of either the departure or arrival fixes, or both; with or without fix names.
- ***Status:*** provides information regarding the status of each runway.
- ***Wind:*** provides an overview of the wind conditions, included current and expected winds.
- ***Special Events:*** provides information regarding special events in the area that will impact airport operations.

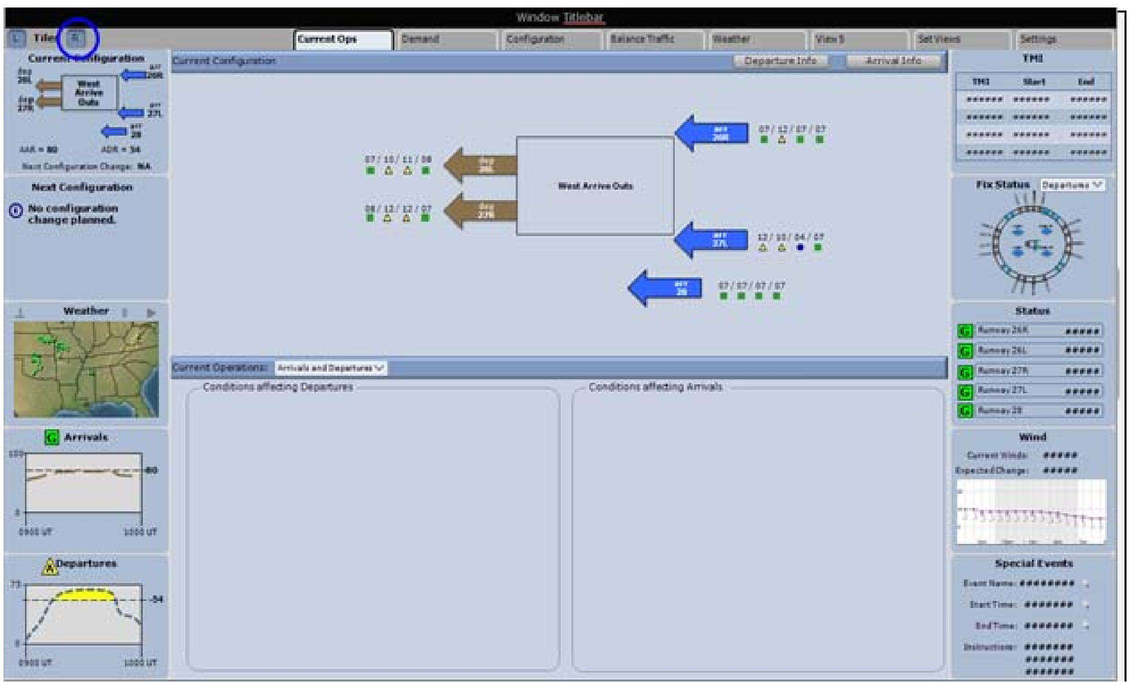

Figure 19. Configurable tiles on the left and right side of the display provide global SA.

Current Operations Tab

The Current Operations ("Current Ops") tab provides an overview of the current configuration (Figure 20 and Figure 21). In addition to providing a visual representation of the current configuration, it provides the status of demand versus capacity as well as detailed information regarding the mix of aircraft that is projected within each 15 minute interval. The Current Ops tab includes the following:

- Information about the current traffic situation by providing details about the number and type of aircraft arriving or departing in each 15 minute time interval.
- Visual depiction of the current configuration, including the number of aircraft arriving or departing in consecutive 15 minute blocks and the status of demand versus capacity for each of those 15 minute blocks.
- Detailed information regarding the type of aircraft expected in each 15 minute block of time. This information can be shown via bar graphs or a summary table.

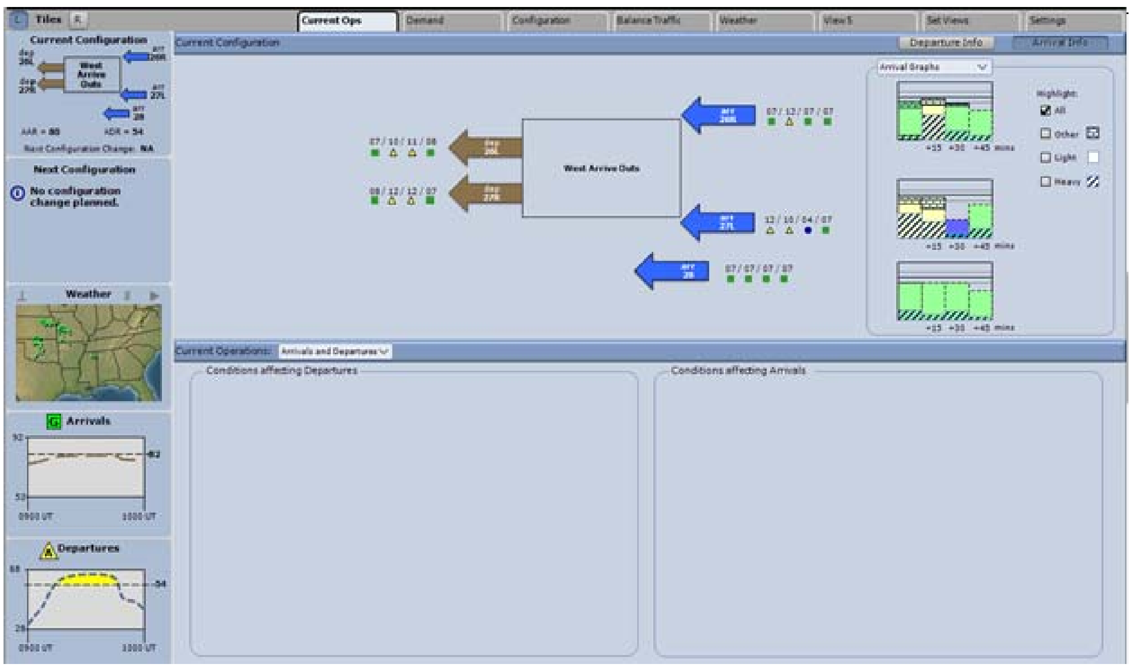

Figure 20. Current Operations Tab showing arrival information.

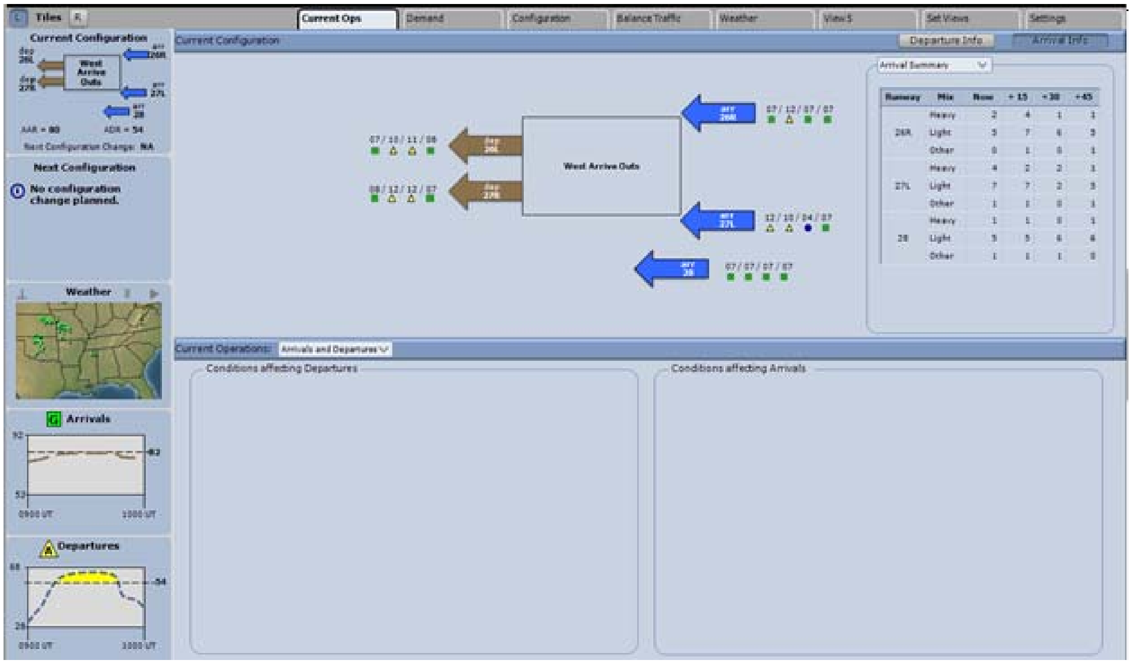

Figure 21. Current Operations Tab showing departure information.

Demand Tab

The Demand tab supports the user in understanding projected demand / capacity, while simultaneously tracking what is happening on the airport surface (Figure 22 and Figure 23). Filters are provided that will allow the user to customize this view such that it supports understanding how changes in the airport surface (e.g., availability of runways) and changes within the environment may affect capacity. The Demand tab includes the following:

- An overview of the movement of aircraft on the airport surface and the arrival runway / departure runway / gate each aircraft is moving towards.
- The sequence of aircraft arriving or departing from each runway.
- Additional information related to the airport layout.

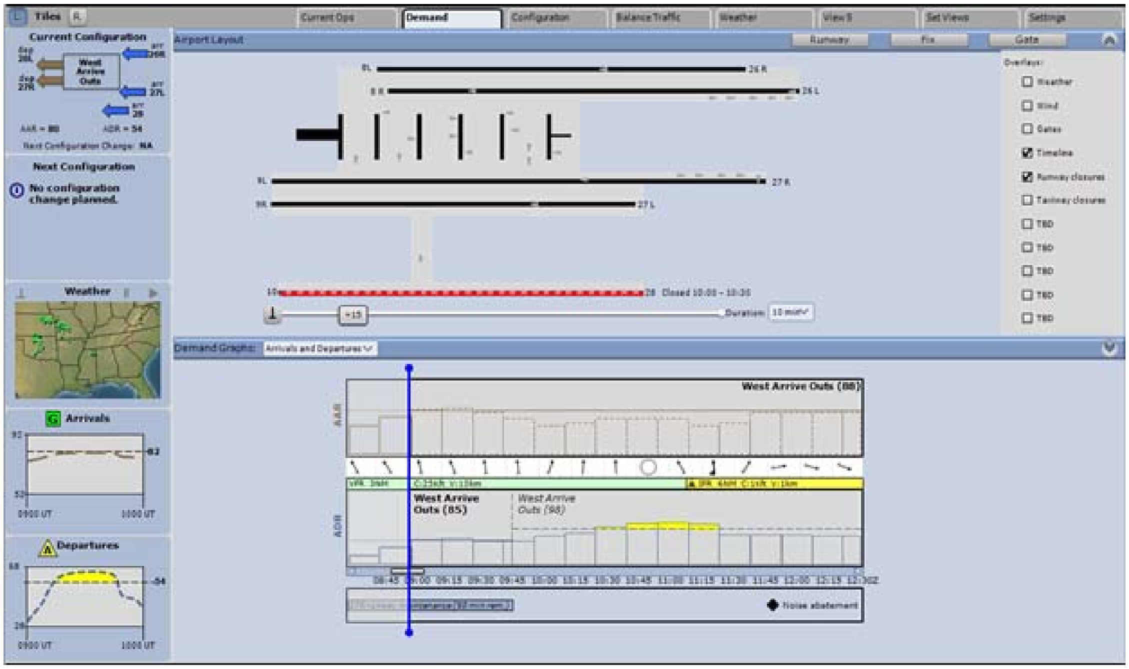

Figure 22. Demand Tab showing airport layout with arrivals and departures.

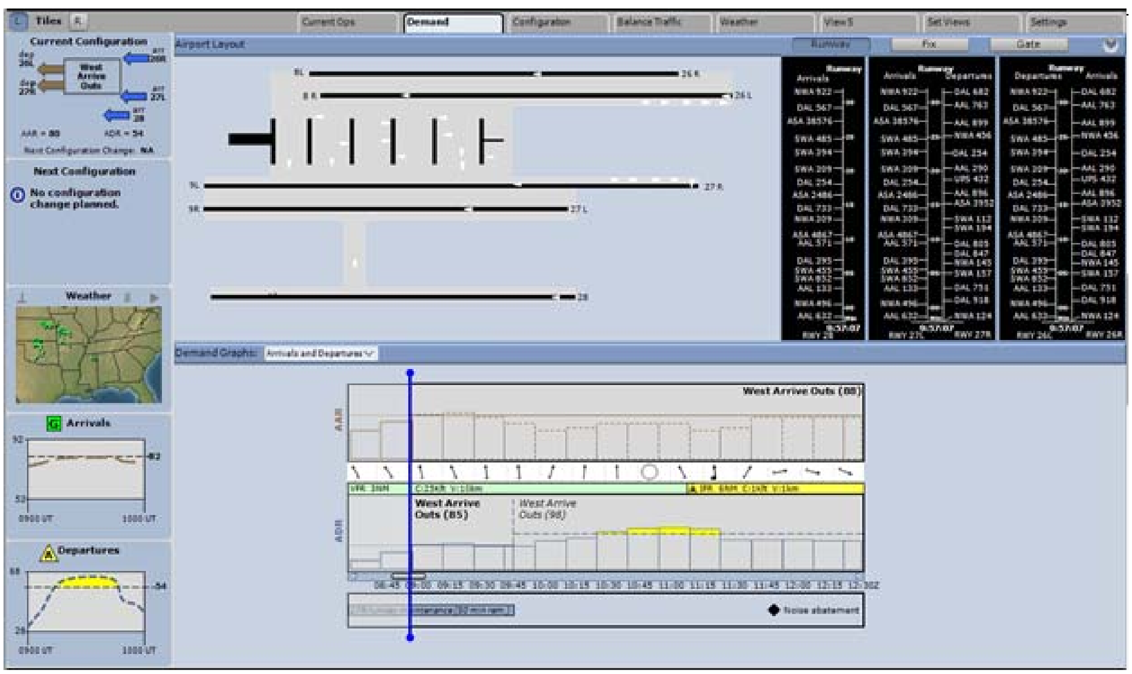

Figure 23. Demand Tab showing runway information.

Configuration Tab

The Configuration tab allows the user to change runway configuration or runway utilization. Figure 24 shows the Configuration page with the current plan. Figure 25 shows the result of selecting “Plan Layout Change” in order to alter the configuration, and Figure 26 shows the result of selecting “Compare Options,” which supports the evaluation of candidate configurations. It shows past and projected demand and capacity graphs for arrivals and departures as well as a timeline for aircraft movement per runway. The Configuration tab includes the following:

- Interactive graphs providing relevant information superimposed on graphs depicting arrivals and departures.
- Visual indication when demand is nearing or exceeds capacity.
- Visual representation of the current time and the planning line associated with the “what-if analysis.”
- Visual depiction of the current layout and the next planned layout.
- Time of the planned configuration change and time remaining until that change is scheduled to occur.
- Interactive planning feature that allows the user to create new plans for layout changes. This tool allows the user to create a fully automated plan, a mixed initiative plan, or a completely manual plan.
- Ability to select plans from a list of saved plans which can then be compared to evaluate which plan is best for the situation.
- Details regarding which aircraft are assigned to a specific runway for either departure or arrival.

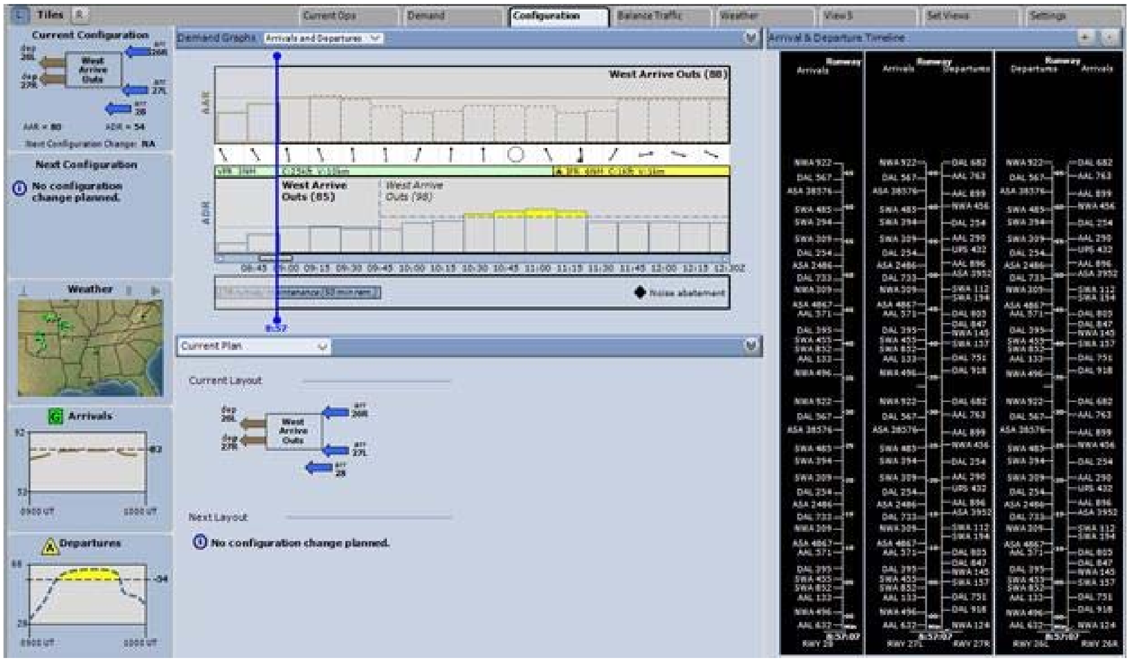

Figure 24. Configuration Tab showing current plan.

Figure 25. Configuration Tab showing "Plan Layout Change" selection**.**

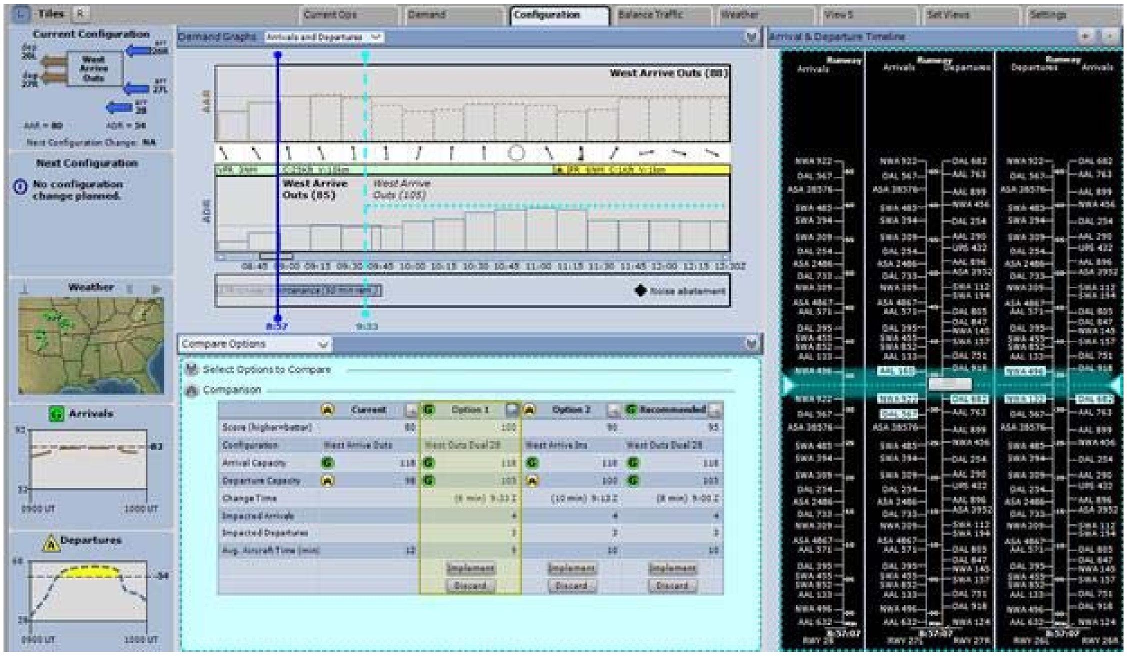

Figure 26. Configuration Tab showing "Compare Options" selection.

Balance Traffic Tab

The Balance Traffic tab provides the user with a workspace to adjust the mapping between fixes and runways in order to maximize airport efficiency (Figure 27 and Figure 28). This tab provides detailed information related to the demand across individual fixes and runways, and allows the user to view how modifications to the fix-to-runway mapping impact throughput. The Balance Traffic tab includes the following:

- Interactive graph depicting the current and projected relationship between demand and capacity for each runway.
- Tools to enable the operator to change which fixes are mapped to which runways in order to balance traffic across the airport for maximum efficiency.
- Overview of the wind conditions, including current and expected winds.
- Overview of projected traffic flow in 15 minute blocks.

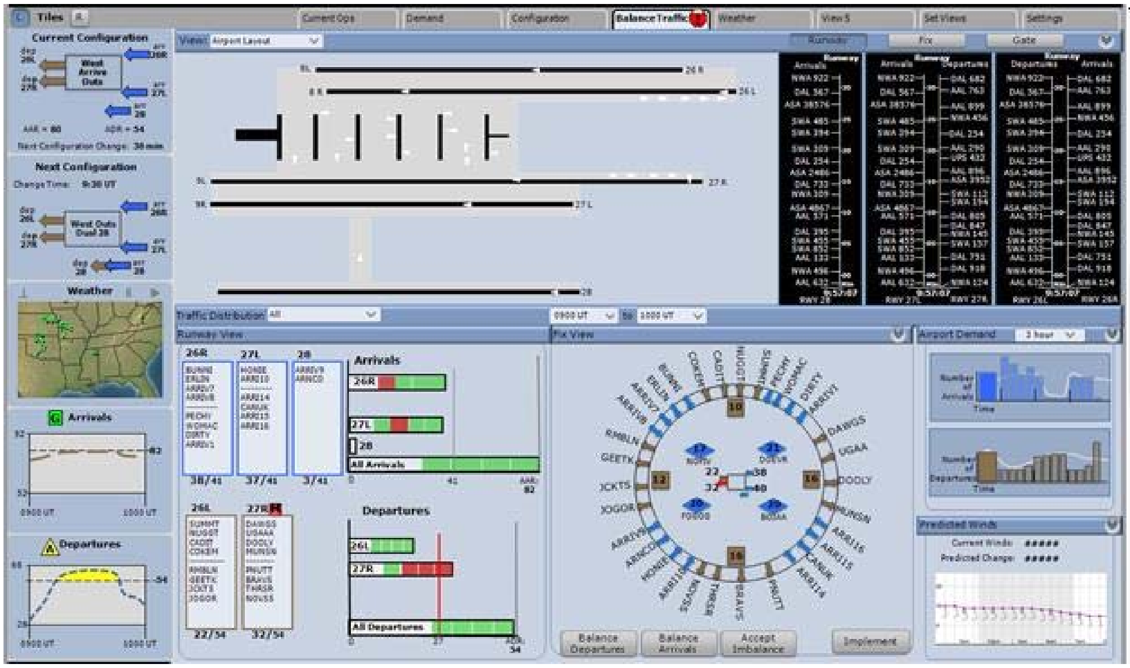

Figure 27. Balance Traffic Tab showing current traffic distribution.

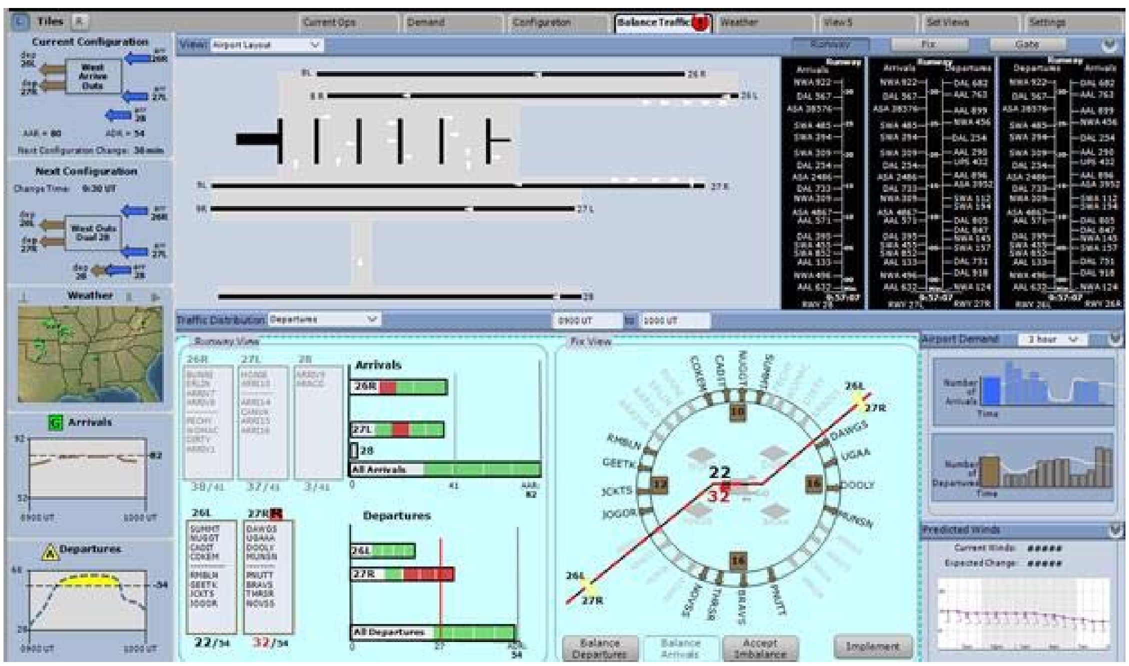

Figure 28. Balance Traffic Tab showing contingency planning.

User-Centered Iterative Design & Evaluation

The SAOD process facilitates the elicitation of end-user feedback frequently throughout the design cycle. The recommended evaluation path begins with informal feedback sessions, moves to low-fidelity cognitive walkthroughs, proceeds to part-task testing, high-fidelity human-in-the-loop simulation, and finally field testing. While the NASA-funded effort included only development through workshop evaluations, this section provides guidance for more fully assessing the SORM tool.

Workshop Evaluations

Two workshops were conducted to support the iterative design of the SORM GUI. Workshop 1 occurred on 26-27 July 2012, and included the participation of three air traffic control specialists as subject matter experts (SMEs). As a group, these persons represented experience at a variety of facilities (Denver ARTCC, Minneapolis Enroute and TRACON, Los Angeles (LAX), Atlanta TRACON and Tower, and Keesler and Yakota (Japan) Air Force Bases), and represented positions for TFM, ATC training department and instructor, Front Line Manager, and control specialist). Workshop 1 began with an overview of the SORM objectives and review of the methodology and sources used to derive information requirements. Participants were asked to comment on the sufficiency and validity of the sources and methodology. These were deemed appropriate, but participants stressed the interaction of their positions with other personnel, and this was taken as direction to expand the types of participants in Workshop 2. Following this review, static prototype displays that were developed based on the requirements analysis methods were presented to participants. In this first presentation, no additional information was provided, and participants were asked to provide their first impressions of what information was provided, what controls were available to them, and how they would use these affordances to manage airport surface resources. Feedback focused on ensuring that information and controls were intuitive, and that terminology and display formatting was consistent with expectations. After gathering these first impressions, the same prototype displays were then described to participants, and further discussion centered on: whether information and functionality was appropriate and sufficient to support operations, how the functionality presented compared to that provided by the amalgam of systems currently used, the degree to which different facilities have different constraints and characteristics that affect

configuration management, what alerting and notifications should be provided (and the logic/thresholds that should underpin these), and what types of views would be useful together. Workshop 1 concluded with a discussion of personal airport surface/runway configuration experiences that participants encountered that were challenging, and a discussion of the typical pattern of configuration changes at their facilities. Following Workshop 1, the GUI design was modified to incorporate recommended changes, and scenarios based on participant input were constructed in support of Workshop 2.

Workshop 2 was conducted on 30-31 August 2012. Two of the three ATC specialists that attended Workshop 1 also participated in Workshop 2. In addition, to further investigate the collaborative nature of airport surface runway management, three additional SMEs were invited. Expertise included in these additional participants included: AOC operator, AOC administrator, airfield operations officer, director of airborne traffic control operations; and experience at Dallas Fort Worth, Newark, and Atlanta facilities. In addition, one participant was actively involved in research and development for future Tower and TRACON tools at another laboratory. Workshop 2 provided all participants with a review of the SORM objectives, and obtained first impressions of the revised SORM GUI prototype display views. Feedback was obtained on these as a group, the same discussion points were reviewed as in Workshop 1, and additional discussion focused on the nature of collaborative decision making and communication support among different types of operators in the system. On the second day of Workshop 2, participants were divided into two smaller groups, each comprised of at least one ATC specialist and one person with AOC experience, for detailed discussion and walk-through of how surface runway management would unfold with respect to a set of scenarios, how the SORM GUI would be used to support this effort, and how collaboration occurs (what are roles, when do operators communicate, what information required to be available to each). Participants were asked to consider the following scenarios: routine start-of-shift assessment, projected weather change that would induce a wind shift at the airport, unexpected runway closure due to aircraft emergency, coordinated flow with a nearby airport experiencing configuration changes, and release of a ground hold affecting one side of the airport. Results of the scenario-based discussions were reviewed with the group as a whole, and a summarized version of the earlier GUI critiquing session was presented to the group for validation. Workshop 2 concluded with an exercise, completed by SMEs independently, to ascertain the priority of information elements and views provided by the GUI. This exercise was conducted to structure a phased implementation of the GUI concepts into a dynamic display prototype.

Cognitive Walkthroughs

Cognitive walkthroughs are a low-fidelity user test approach that gathers objective and subjective feedback from users. The storyboards used in this phase can range from static storyboards to a prototype with limited interactivity. During a cognitive walkthrough, users are asked a series of questions about what information the screen is trying to convey, how a certain task would be performed, and what results they expected to see reflected on the GUI after they take a specified action. Additional information is gathered in pretest and posttest surveys to support the analysis of the user's feedback.

Part-Task Testing

Part-task testing involves implementing a restricted set of design features with which the participant can dynamically interact. Typically it involves implementing a view or a part of a view and asking the participant to use the prototype to complete a task or a series of tasks. The prototype typically populates the dynamic fields from a database and has a limited set of real-time functionality sufficient to support the goals of the evaluation. Part-task testing can be useful to identify insufficiency of interface controls to take desired actions, and issues associated with the system dynamics of the aspect simulated.

High-fidelity Simulation

High fidelity, human-in-the-loop simulation evaluations are complex events that require near-full to full implementation of a defined set of functionality such that it supports real-time interactions between the user and the system as well as between multiple users, as appropriate. A variety of types of data are collected during these events including demographic information about each participant, subjective evaluations of the design, subjective and objective measures of situation awareness, objective and subjective measures of workload, performance metrics, error rates, time on task, and other targeted metrics, as appropriate. The evaluation can be either a comparison against a baseline system (to demonstrate relative effectiveness and usability) or it can be a single evaluation aimed at identifying operability issues for further refinement and/or establishing acceptability in a representative operational environment.

Evaluation of the SORM GUI should address its utility to the system, usefulness, and usability in supporting effective runway configuration management.

- **Utility**: Does the SORM GUI improve runway configuration management, and ultimately airport efficiency?

- **Usefulness:** Is the SORM GUI accurate and complete in the functionality provided? If not, what functionality is missing? Do users consider it a useful tool? Are other tools required/desired to support the SORM GUI? Is Situation Awareness improved? Is workload level acceptable? Is the system perceived as reliable and trustworthy? Does the system support collaborative decision-making among operators involved in runway configuration/use change?

- **Usability**: Is the SORM GUI intuitive and easily used? Is required information easily available and understandable, and presented in a manner that implies appropriate use? Are required interface controls available, evident, and appropriate to enact desired actions? Are mistakes difficult to make, and easy to identify and reverse if made?

Field Evaluation

Ultimately, the resulting design should be assessed in the context of real operations and with real operators. While this GUI was intended to incorporate all sources of information necessary for the surface runway management decision, assessment in actual operations would reveal residual reliance on existing peripheral, but supportive, information sources (e.g., weather radar sources). In addition, evaluation in the real operational context will provide an opportunity to assess the manner in which this new GUI affects communication among operators as surface runway management decisions are considered.

Summary & Recommendations

The objective of this effort was to develop the prototype design of a graphical user interface for the SORM tool such that it effectively supports use by air traffic personnel, principally those in TRACON and Tower facilities. This design process generated initial requirements. These were instantiated in an initial prototype which was subjected to review by subject matter experts. A revised prototype was further analyzed, resulting in further refinement and validation of interface features and functions. Participating SMEs generally responded positively to the notion of using the SORM tool with such an interface in operations.

While some of the recommendations from the second GUI workshop are reflected in the design presented in this document, additional recommendations were identified. These include::

- Provide more detailed information regarding fleet mix/aircraft types.
- Consider adding parameters that support self-evaluation of performance.
- Allow the user to “drill down” to gain additional detailed information regarding aircraft (e.g., call sign, type, push time, departure fix, destination point, arrival gates, etc.).
- Incorporate weather into the graphical views of the demand graphs.
- Provide more detailed wind information and show how these impact operations.
- In addition to runway configuration changes, provide recommendations for alternative ways to handle situations in which demand nears or exceeds capacity (e.g., implement delays, balance arrival versus departures, etc.).
- Provide a means to view and compare multiple considered configuration changes.
- Create templates to work from, that characterize the standard “plays” for a typical day, as well as foreseeable special circumstances.
- Further define meaningful alert conditions and thresholds.

Further consideration of these features should be explored by following the same user-centered design process: explicating requirements with users, and allowing users to critique through Cognitive Walkthrough the resulting prototype. Once satisfied that information requirements and user interface controls support the task, more contextualized evaluations should be conducted: Part Task testing with a dynamic prototype actuated with data; High-Fidelity Simulation in which this system is tested in a realistic, but simulated, environment; and finally field observation once incorporated in relevant operational contexts.

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Appendix A. Acronym List

Acronym	Definition
AAR	Airport Acceptance Rate
ADR	Airport Departure Rate
AOCC	Airline Operations Control Center
APREQ	Approval Request
ARMD	NASA's Aeronautics Research Mission Directorate
ARTCC	Air Route Traffic Control Center
ATCSCC	Air Traffic Control System Command Center
ATCT	Air Traffic Control Tower
ATM	Air Traffic Management
CADRS	Combined Arrival / Departure Runway Scheduling
EDCT	Expect Departure Clearance Time
ETMS	Enhanced Traffic Management System
ETA	Estimated Time of Arrival
FA	Functional Analysis
FAST	Final Approach Spacing Tool
GDP	Ground Delay Program
GDTA	Goal Directed Task Analysis
GUI	Graphical user interface
ID	Identifier
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
JPDO	Joint Planning and Development Office, FAA for Next Generation Airspace System
LAHSO	Land and Hold Short Operations
LIMC	Low Instrument Meteorological Conditions
MINIT	Minutes in Trail
MIT	Miles in Trail
MVMC	Marginal Visual Meteorological Conditions

NAS	National Air Space
NASA	National Aeronautics and Space Administration
nm	Nautical Miles
ROR	Runway Occupancy Rate
ROT	Runway Occupancy Time
SAOD	Situation Awareness Oriented Design
SME	Subject Matter Expert
SORM	System Oriented Runway Management
SRCM	Strategic Runway Configuration Management
SUA	Special Use Airspace
TFM	Traffic Flow Manager(Management)
TMA	Traffic Management Advisor
TMC	Traffic Management Coordinator
TMI	Traffic Management Initiative
TRACON	Terminal Radar Approach Control
TRCM	Tactical Runway Configuration Management
VIP	Very Important Person (aircraft requiring special handling)
VMC	Visual Meteorological Conditions

Appendix B. SORM GUI Interface Controls

Tab	Section	Type	Label	Description
NA	Log on Screen	Text Box	User Name	Input User Name
NA	Log on Screen	Text Box	Password	Input Password
NA	Log on Screen	Button	Submit	Submit User Name and Password
NA	Log on Screen	Drop Down	Select Role	Select Role
NA	Log on Screen	Drop Down	Profile	Select Profile
NA	Log on Screen	Button	Submit	Submit Role and Profile
NA	Navigation Bar	Button	L	Turn on / off Left tile panel
NA	Navigation Bar	Button	R	Turn on / off Right tile panel
NA	Navigation Bar	Tab	Current Ops	Changes view to Current Ops view
NA	Navigation Bar	Tab	Demand	Changes view to Demand view
NA	Navigation Bar	Tab	Configurati on	Changes view to Configuration view
NA	Navigation Bar	Tab	Balance Traffic	Changes view to Balance Traffic view
NA	Navigation Bar	Tab	Weather	Changes view to Weather view - Tab not developed
NA	Navigation Bar	Tab	View 5	Changes view to View 5 - Tab not developed
NA	Navigation Bar	Tab	Set Views	Changes view to Set Views - Tab not developed
NA	Navigation Bar	Tab	Settings	Changes view to Settings - Tab not developed
NA	Weather Tile	Button	Icon	Returns the radar loop to the current time
NA	Weather Tile	Button	Icon	Stops the radar loop
NA	Weather Tile	Button	Icon	Plays a loop of the radar for the defined period of time
NA	Fix Status Tile	Drop Down	NA	Toggles tile view between 3 options: Departures, Arrivals, All
Current Ops	Current Configuration Part Header	Button	Departure Info	Shows graphs Departure Graphs / Table
Current Ops	Current Configuration Part Header	Button	Arrival Info	Shows Arrival Graphs / Table.
Current Ops	Current Configuration - Arrival Info	Drop Down	NA	Toggles view between 3 options: Arrival Graphs, Arrival Summary

Current Ops	Current Configuration - Arrival Info - Highlight	Checkbox	All	Shows all types of arrivals on the arrival graph
Current Ops	Current Configuration - Arrival Info - Highlight	Checkbox	Other	Shows "other" arrivals on the arrival graph
Current Ops	Current Configuration - Arrival Info - Highlight	Checkbox	Light	Shows "Light" arrivals on the arrival graph
Current Ops	Current Configuration - Arrival Info - Highlight	Checkbox	Heavy	Shows "Heavy" arrivals on the arrival graph
Demand	Airport Layout	Button	Runway	When active, shows the aircraft per runway
Demand	Airport Layout	Button	Fix	When active, shows the aircraft per fix
Demand	Airport Layout	Button	Gate	When active, shows the aircraft per gate
Demand	Airport Layout	Button	Show / hide icon	Shows / hides the settings panel.
Demand	Airport Layout - Settings Panel	Checkbox	Weather	When selected shows weather on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	Wind	When selected shows wind on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	Gates	When selected shows gates on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	Timeline	When selected shows timeline on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	Runway closures	When selected shows runway closures on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	Taxiway closures	When selected shows taxiway closures on the airport layout
Demand	Airport Layout - Settings Panel	Checkbox	TBD	Provides space to expand the options to show on the airport layout

Configuration	Demand Graphs - Title Bar	Drop Down	Demand Garphs	Provides mechanism to select what graphs to display in the part. Options = Arrivals and Departures (default), Arrivals only, Departures only
Configuration	Demand Graphs - Title Bar	Button	Show / hide icon	Shows / hides the Demand Graphs Part settings panel.
Configuration	Demand Graphs Part - Settings Panel	Drop Down	NA	Provides mechanism to select between different graphs to view. Options = moving average, 5-min bar, 10-min bar, 15-min bar, 30-min bar, 60-min bar
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Stacked Graphs	When selected display a stacked bar graph or stacked curved graph depending on what is selected in the drop-down
Configuration	Demand Graphs Part - Settings Panel	Scroll bar	Up arrow icon	Scrolls list up
Configuration	Demand Graphs Part - Settings Panel	Checkbox	AAR	Turns on / off Airport Arrival Rate (AAR) line
Configuration	Demand Graphs Part - Settings Panel	Checkbox	ADR	Turns on / off Airport Departure Rate (ADR) line
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Time to change	Turns on / off dashed line for showing the next layout change.
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Historical AAR	Shows / hides historical AAR plot
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Historica ADR	Shows / hides historical ADR plot
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Departure pushes	Shows / hides known push events in the Constraints Graph
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Arrival pushes	Shows / hides known push events in the Constraints Graph
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Runway restrictions	Shows / hides runway restrictions (e.g., closures) in the Constraints Graph
Configuration	Demand Graphs Part - Settings Panel	Checkbox	Weather	Turns on / off the Weather Graph and the Wind Barb Graph

Configuration	Demand Graphs Part - Settings Panel	Checkbox	Special Events	Shows / hides special events in the Constraints Graph (e.g., noise abatement)
Configuration	Demand Graphs Part - Settings Panel	Scroll bar	Down Arrow Icon	Scrolls list down
Configuration	Demand Graphs Part - Settings Panel	Button	Save as view	On selection, put a new view button in the part titlebar associated with the current settings
Configuration	Demand Graphs Part - Settings Panel	Button	Manage Views	Allows the user to manage custom views. Functionality TBD
Configuration	Demand Graphs Part - Interactive Control	Timeline Slider	NA	Scrolls the time window for Arrival & Departure Timeline Part
Configuration	Demand Graphs Part - Interactive Control	What-if Line + What-if Slider	NA	Adjust the capacity slider up or down to select a corresponding runway configuration or utilization.
Configuration	Planning Part - Current Plan	Drop Down	NA	Enables selecting between different panels for (1) looking at the current (and upcoming) plan, (2) for making what-if analysis and planning layout changes, and (3) for comparing what-if analysis and plan options.
Configuration	Planning Part - Current Plan	Button	Show / hide icon	Shows / hides the settings panel associated with this part (TBD).
Configuration	Planning Part - Plan Layout Change	Drop Down	Options	Enables selecting between different what-if analyses with different automation level. Options are New - Mixed Auto, New - Manual, New - Predefined, Custom (user defined)
Configuration	Planning Part - Plan Layout Change	Button	Plan	Used for creating a new what-if option
Configuration	Planning Part - Plan Layout Change	Button	Discard Option	Used for discarding or deleting a what-if option
Configuration	Planning Part - Plan Layout Change	Button	Generate	Used for generating runway configuration options for the current what-if option
Configuration	Planning Part - Plan Layout Change	Button	Implement	Used for putting the specific runway configuration into effect
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View	Drop Down	Change Time	Used for specifying a preferred change time

Configuration	Planning Part - Plan Layout Change - Mixed-Auto View	Button	Automation icon	Automation provides recommendations for change time
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Weather	Button	Show / hide icon	Used to expand / collapse the Weather group
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Weather	Drop Down	Operations	Specifies operating mode. Options are VFR and IFR
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Weather	Drop Down	Visiblity	Specifies visibility. Options are Unlimited and TBD
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Weather	Drop Down	Ceiling	Specfies celing. Options are Unlimited and TBD
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Weather	Drop Down	Wind	Specfies wind direction. Options are N, E, S, W, NE, SE, SW, NW
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Runways	Button	Show / hide icon	Used to expand / collapse the Runway group
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Runways	Table - checkbox es	Arrival / Departure	Used to select runways for automation to consider in calculations for making a recommendation
Configuration	Planning Part - Plan Layout Change - Mixed-Auto View - Runways	Checkbox	Override	Used to override runway selection restrictions

Configuration	Planning Part - Plan Layout Change - Manual View	Table - checkboxes	Arrival / Departure	Used to manually specify which runways to use for arrivals, departures, or both
Configuration	Planning Part - Plan Layout Change - Manual View	Checkbox	Override	Used to override runway selection restrictions
Configuration	Planning Part - Plan Layout Change - Predefined	Drop Down	Change Time	Used for specifying a preferred change time
Configuration	Planning Part - Plan Layout Change - Predefined	Button	Automation icon	Automation provides recommendations for change time
Configuration	Planning Part - Compare Options	Button	Show / hide icon	Used to expand / collapse the Options to Compare section
Configuration	Planning Part - Compare Options	Table - checkboxes	NA	Used to select specific options to compare
Configuration	Planning Part - Compare Options	Button	Compare	Used to calculate the comparison table
Configuration	Planning Part - Compare Options	Button	Show / hide icon	Used to expand / collapse the Comparison section
Configuration	Planning Part - Compare Options	Button	Preview Icon (magnifying glass)	Highlights the option that is being previewed
Configuration	Planning Part - Compare Options	Button	Implement	Used to implement the option
Configuration	Planning Part - Compare Options	Button	Discard	Used to discard the option
Configuration	Arrival & Departure Timeline Part	Button	Minus sign	Zooms out to make the timeline shown in the window longer
Configuration	Arrival & Departure Timeline Part	Button	Plus sign	Zooms in to make the timeline shown in the window shorter
Configuration	Arrival & Departure Timeline Part - Recommendations	What-if Slider	NA	Used to specify a what-if configuration change time
Balance Traffic	Balance Traffic Part Title Bar	Drop Down	Traffic Distribution	Selection changes the data feeding into the Runway View and Fix Few tiles. Options = All, Arrivals, Departures

Balance Traffic	Balance Traffic Part Title Bar	Drop Down Combo	(time)	Select the start time for the Balance Traffic Part
Balance Traffic	Balance Traffic Part Title Bar	Drop Down Combo	(time)	Select the end time for the Balance Traffic Part
Balance Traffic	Fix View	Button	Show / hide icon	Used to show / hide the settings panel for the Fix View
Balance Traffic	Fix View - Settings Panel	Scroll bar	Up arrow icon	Scrolls list up
Balance Traffic	Fix View - Settings Panel	Checkbox	Fix ID	Turns on / off Fix ID
Balance Traffic	Fix View - Settings Panel	Checkbox	Inner Fix Demands	Turns on/off Inner Fix Demands (TBD)
Balance Traffic	Fix View - Settings Panel	Checkbox	Out Fix Demands	Turns on/off Outer Fix Demands (TBD)
Balance Traffic	Fix View - Settings Panel	Checkbox	Airport Demands	Turns on/off Airport Demands (TBD)
Balance Traffic	Fix View - Settings Panel	Checkbox	Fleet Mix	Turns on/off Fleet Mix (TBD)
Balance Traffic	Fix View - Settings Panel	Scroll bar	Down Arrow Icon	Scrolls list down
Balance Traffic	Fix View - Settings Panel	Button	Save as view	On selection, put a new view button in the part titlebar associated with the current settings
Balance Traffic	Fix View - Settings Panel	Button	Manage Views	Allows the user to manage custom views. Functionality TBD
Balance Traffic	Fix View	Button	Balance Departures	Puts the interface into planning mode and allows the user to interact with the Fix Wheel to balance departures
Balance Traffic	Fix View	Button	Balance Arrivals	Puts the interface into planning mode and allows the user to interact with the Fix Wheel to balance arrivals
Balance Traffic	Fix View	Button	Accept Imbalance	Tells the system to accept the imbalance and remove any alerts
Balance Traffic	Fix View	Button	Implement	Implements the changes made during the planning session entered by selected either Balance Departures or Balance Arrivals
Balance Traffic	Predicted Winds	Button	Show / hide icon	Used to show / hide the settings panel for the Predicted Wind section (TBD)
Balance Traffic	Airport Demand	Drop down	Airport Demand	Provides options to customize the time frame shown in the graph. Options range from now to 4 hours, in 30 minute increments

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14. ABSTRACT
The objective of this effort was to develop a graphical user interface (GUI) for the National Aeronautics and Space Administration's (NASA) System Oriented Runway Management (SORM) decision support tool to support runway management. This tool is expected to be used by traffic flow managers and supervisors in the Airport Traffic Control Tower (ATCT) and Terminal Radar Approach Control (TRACON) facilities.

15. SUBJECT TERMS
Air traffic control; Airport towers; Graphical user interface; National airspace system; Runways

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